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Introduction:

Prior to the dismantling of the ARE a request was made for a visual examination of certain BeO blocks from the core of the reactor after shut-down. Specifically, a block from the center region, the outer region, and several of the cut BeO blocks from the core were examined. Fig. 1 shows the stacking arrangement of the BeO blocks in the reactor, the larger serpentine tubes that carried the fuel surrounded by the split BeO blocks, and the small diameter tubes that carried the sodium surrounded by the whole BeO blocks. The small spaces between the BeO blocks were filled with slow moving sodium which facilitated better heat transfer. The object of this examination was to determine the extent of penetration of sodium and damage affected to the BeO blocks during the operation of the ARE.

Examination:

Figs. 2, 3, and 4 show the BeO blocks as they appeared after removal from the core of the ARE. Worthy of mention is the fact that no sodium stripping of the BeO blocks after removal from the core of the reactor was necessary; i.e., the blocks were relatively clean of sodium after the core was drained. Therefore, it is safe to say that any damage seen in the BeO blocks occurred during the operation of the ARE or was present in the as-fabricated condition. The post-test handling could not have inflicted further damage.

A block which surrounded a fuel serpentine in the center region of the core is shown in Fig. 2 and has been designated as R-10. One half of the block has fractured and many macro-cracks can be seen. In a report by Doney¹ he notes that concerning tests run on the as received BeO blocks "... nearly all blocks have at least one crack and some blocks contain several." In comparing the edges of this block with photographs of the blocks before installation in the reactor, slight erosion of the edges is noticed. There is comparatively little difference between the amount of erosion at the corners at the top and bottom of the block, and along the longitudinal edges. A slight amount of spalling, or flaking apparently occurred on some of the BeO blocks; small flakes of BeO can be seen adhering to the surface of the left portion of the block.

¹ "Structure of BeO Block with the 1 1/8" Central Hole", L. M. Doney, Nov. 17, 1952. ORNL Central Files Number 52-11-146. p.1.

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Fig. 3 shows the condition of a BeO block from the outer region of the core designated as R-9. This block also surrounded a fuel serpentine. The sodium hydroxide droplets, which can be seen on the surface of the BeO blocks, were caused by small amounts of sodium that remained on the blocks after removal from the reactor core. There were no complete fractures in this block, but as in R-10, many macro-cracks are visible. Except for the fracture, the general appearance of R-9 is similar to the R-10 block. The R-9 block was sectioned transversely to determine the depth of penetration of the sodium into the block. The transverse sections were immersed in a dilute HCl solution, then dipped into a water rinse, blotted and swabbed with a 3% solution of phenolphthalein. The blocks were then allowed to "set" for 5 minutes and then photographed. The results are shown in Figs. 5 and 6. The darker areas denote a more porous area which has a higher sodium content (now in the form of sodium hydroxide), while the light areas denote an absence of sodium penetration and therefore a more dense area. Since sodium was retained in any cracks or crevices the macro-cracks show up as dark lines, except in the case of larger cracks, which retained a considerable amount of acid from the acid bath which continued to seep out neutralizing the sodium (hydroxide). These results agree with those concerning the porosity of BeO blocks investigated by Doney, i.e., the central core of these blocks reveal a more porous structure in comparison to the periphery. The only thing disclosed in this examination which was not pointed out earlier is that zones of higher density in comparison to the rest of the block remained. Macro-cracks did not propagate through these areas. This was the only BeO block investigated for sodium penetration, but a relatively good representative area is believed to have been shown here.

Two of the three cut BeO blocks designated as R-12, chosen for examination were fractured during the operation of the ARE; however, there are no macro-cracks visible, as shown in Fig. 4. The surface conditions of the cut BeO blocks compare with those of blocks R-9 and R-10.

Conclusions:

In order to determine how well the BeO blocks that were in the core of the ARE withstood the experiment, blocks from the central region, the outer region, and cut BeO blocks were removed after shut-down of the reactor for examination. During the course of the examination several points of interest were noted:

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1. Fractured BeO blocks were found across the entire traverse of the core.
2. With the exception of the cut BeO blocks, both the fractured and the whole blocks contained macro-cracks; many of which were probably initiated during the operation of the reactor. The cut BeO blocks did not contain any visible macro-cracks.
3. Remaining high density zones of BeO were found toward the periphery of the blocks; the macro-cracks did not propagate through these zones.
4. The core areas of the blocks were very porous in comparison to the peripheral areas.
5. The corners and edges of the blocks were slightly rounded which indicated a small amount of erosion had occurred during the operation of the reactor.
6. Although there was no direct evidence on any of the surfaces of the blocks, there is a possibility that light spalling or flaking of the BeO had occurred.

In general, the BeO blocks withstood the operational conditions imposed in the Aircraft Reactor Experiment reasonably well.

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ORNL PHOTOGRAPH NO. 11208
Fig. 1 ARE Reactor Core Showing Stacking Arrangement of BeO Blocks Around the Fuel Serpentine, Sodium Lines, and the Instrumentation and Control Rod Tubes.

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R-10

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Fig. 2 BeO Block R-10 Removed from the Central Region of the Reactor Core. Note fracture of the block on the right and macro-

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R-9

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Fig. 3 BeO Block R-9 Removed from the Outer Region of the Reactor Core. Note macro-cracks in both sections.

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R-12

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Fig. 4 Cut BeO Blocks from the ARE Core. Two of the three blocks have fractured. Note absence of macro-cracks.

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Fig. 5 Transverse Section of BeO Block R-9. Darker areas denote high sodium concentration. Note macro-cracks.

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Fig 6. Remaining Transverse Section of BeO Block R-9. Dark areas denote a high sodium concentration. Note macro-cracks.

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