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AEC RESEARCH AND
DEVELOPMENT REPORT
JANUARY 1971

FISSION GAS RE-SOLUTION RATES

QUARTERLY REPORT NO. 2
OCTOBER 1 TO DECEMBER 31, 1970

M. O. MARLOWE

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ABSTRACT

This second quarterly report describes progress in experimental programs and studies to determine the re-solution rates of fission gases in oxide nuclear fuels under irradiation. The furnace and associated inert atmosphere control system for in-cell annealing of the irradiated specimens was assembled and tested. The first dummy unirradiated specimens for transmission electron microscopy was thinned in-cell. A topical report (GEAP–12148) describing the limitations of fission gas bubble growth by the re-solution process was written.

1. INTRODUCTION

This is the second Quarterly progress Report on the status of the experimental programs and studies being conducted to determine the re-solution rates of fission gases in oxide nuclear fuels. The progress in development of the technique for specimen preparation for transmission electron microscopy and equipment for annealing of the specimens in-cell is described. A topical report (GEAP–12148) which was written is summarized.

2. ANNEALING FURNACE

The furnace, portable power supply and temperature control system and atmosphere control system for annealing of the irradiated specimens in-cell was assembled and successfully tested.

3. PREPARATION OF SPECIMENS FOR ELECTRON MICROSCOPY

The technique for thinning of specimens for transmission electron microscopy described in the previous quarterly report (GEAP–12147) was attempted in-cell on a dummy unirradiated UO_2 specimen. The UO_2 disk (approximately 3 mm in diameter and 0.38 mm thick) was mounted on a glass slide with transparent adhesive. The exposed surface of the sample was polished smooth and flat by metallographic techniques. The disk was removed from the glass slide by dissolving the adhesive; it was then remounted in a depression approximately 0.4 mm deep in another glass slide with the polished side adjacent to the slide. The slide and sample were then thinned until the specimen disk was thin enough to transmit red light (approximately 10 micrometers).

In an attempt to release the thinned specimen from the slide by dissolving the adhesive, the very fragile 10-micrometer thick disk was broken into several pieces as a result of the expansion of the adhesive. Subsequent attempts at handling of the remaining pieces revealed that they were not strong enough for loading into the ion milling machine.

Alternate specimen preparation techniques in which the thin section of the specimen is supported by a thicker ring of the specimen or other material to make it strong enough for handling are being explored.

4. TOPICAL REPORT

A topical report (GEAP–12148), "Limitations of Fission Gas Bubble Growth by the Re-Solution Process" was written. In that report it is shown that for power reactor applications, *i.e.*, liquid metal fast breeder reactor conditions, the growth of fission gas bubbles under steady-state operating conditions cannot occur for values of the kinetic parameter,

$$\frac{D}{b'^2\dot{F}} < 10^{11}\ \text{cm}^{-1}$$

where

D is the diffusivity of the gas in the fuel; $\dot{F}$ is the fission rate per unit volume of fuel; and b' is an effective volume in which reinjection of gas atoms can occur because of a fission event; (*i.e.*, $b' = b/\dot{F}$, where b is the more familiar gas atom reinjection probability per unit time).

The present experimental uncertainties in the reinjection probability per unit time, and the gas diffusivity in the fuel, leads to uncertainties in the temperature at which bubble growth can become important, of at least 400°C. However, the minimum temperature for bubble growth is indicated to be at least 1600°C.

It was also observed that whereas fuel swelling because of fission gases may be small and predictable for steady-state operating conditions, the effect of operation at reduced fission rates, and transients in general (*e.g.*, shutdowns) may give rise to rapid bubble growth and significant incremental fuel swelling.

PREVIOUS REPORTS IN THIS SERIES

1. GEAP—12147, Fission Gas Re-Solution Rates, Quarterly Report No. 1, July 1 to September 30, 1970, September 1970.

2. GEAP—12148, Fission Gas Re-Solution Rates: Limitations of Fission Gas Bubble Growth by the Re-Solution Process, November 1970.

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