Plan

Project No. 29412, 23841

AGR-3/4 Compact 10-2 Examination Plan
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# REVISION LOG

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ACRONYMS

AGR    Advanced Gas Reactor
AGR-3/4 third and fourth AGR program irradiation experiments
DTF    designed-to-fail (coated particles)
FIMA   fissions per initial metal atom
INL    Idaho National Laboratory
LBL    leach-burn-leach
ORNL   Oak Ridge National Laboratory
PIE    post-irradiation examination
TAVA   time-average, volume-average (compact irradiation temperature)
TRISO  tristructural isotropic (coated particles)
UCO    uranium carbide and uranium dioxide (multiphase kernels)
1. INTRODUCTION

This plan describes the post-irradiation examination (PIE) activities to be performed by Oak Ridge National Laboratory (ORNL) on irradiated Compact 10-2 taken from the Advanced Gas Reactor (AGR) experiment, AGR-3/4. This work will be performed in accordance with the general objectives outlined in the AGR-3/4 PIE Plan¹ and guidance in the ORNL PIE Statement of Work.²

2. FUEL COMPACT DESCRIPTION

The fuel specimen contains tristructural isotropic (TRISO)-coated driver fuel particles with kernels containing mixed uranium carbide and uranium oxide (UCO), as well as 20 designed-to-fail (DTF) particles consisting of UCO kernels with ~20 µm thick, anisotropic, high-density pyrolytic carbon coatings that were expected to crack to expose the kernel during irradiation. The compact was irradiated in Capsule 10 of the AGR-3/4 test train in the northeast flux trap of the Advanced Test Reactor at Idaho National Laboratory (INL).³ Table 1 shows some identifiers and irradiation conditions for AGR-3/4 Compact 10-2.

<table>
<thead>
<tr>
<th>Compact ID⁴</th>
<th>Container ID</th>
<th>Fabrication ID</th>
<th>Burnup b (%) FIMA</th>
<th>Fast Fluence b (×10²⁵ n/m²)</th>
<th>TAVA (°C)c</th>
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<tr>
<td>AGR-3/4 10-2</td>
<td>AGR351</td>
<td>(LEU03-10T-07 DTF)-Z134</td>
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³ The X-Y naming convention denotes the location in the irradiation test train—Capsule-Level.¹
⁴ Fissions per initial metal atom (FIMA) and fast neutron fluence (Eₙ>0.18 MeV) are based on physics calculations.⁴
⁵ Time-average, volume-average (TAVA) temperature is based on thermal calculations.⁵

3. EXPERIMENTAL OBJECTIVES

Radially deconsolidate the compact in a stepwise fashion and acid leach the particles and matrix debris from each discrete step using a leach-burn-leach (LBL) process, as described in Section 4.1, to measure the compact inventory of actinides and fission products not contained within intact silicon carbide layers.

4. SCOPE OF WORK

4.1 Radial Deconsolidation and Acid Leaching

The fuel compact will be electrolytically deconsolidated in 4–8M nitric acid to break up the matrix material and free the fuel particles (AGR-3/4 UCO compacts have ~1898 TRISO driver fuel particles and 20 DTF particles⁶). The deconsolidation will be done in four segments of roughly equal volumes as shown in Table 2. The first three segments will be radially deconsolidated by rotating the compact about the cylinder axis and collecting particles and matrix debris in three stages. The fourth segment will be deconsolidated by axially deconsolidating the remaining cylinder core, which is expected to contain all the DTF particles (most of which will not be intact). Actual section volumes will be determined by a combination of video and/or still imaging with image analysis software designed for this application.⁷,⁸

The four sets of deconsolidated particles and matrix debris will be individually subjected to an LBL process as described in AGR-CHAR-DAM-37⁹. Particles and matrix debris will be transferred to a Soxhlet thimble, two 24-hour nitric acid leaches in a Soxhlet extractor performed, and the leachates analyzed for actinides and fission products. After these two preburn leaches, the particles and matrix debris from each segment will be “burned” in their respective Soxhlet thimbles by heating at 750°C in air to remove the exposed carbon. After the burn, the burned-back particles and residual ash in each Soxhlet
A compact PIE report will be prepared and will include a description of the experiments performed and all relevant data acquired. Overall data to be reported will include the following, as applicable:

- A compact fractional inventory of fission products released during irradiation, based on as-run inventory calculations and segmented in four radial segments as discussed in Section 4.1.

### 5. QUALITY ASSURANCE

Activities performed at ORNL shall be performed in accordance with applicable ORNL procedures and the ORNL Quality Assurance Plan for Nuclear Research and Development Activities to meet the INL Quality Assurance requirements specified in Inter-Entity Work Order #150293.

### 6. REFERENCES

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