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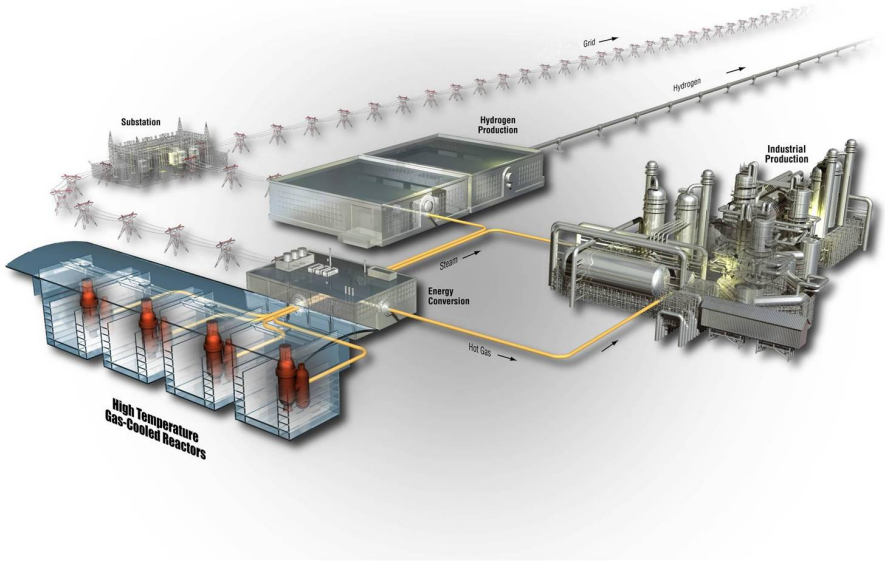
Plan

Project No. 29412, 23841

AGR-3/4 Compact 8-4 Examination Plan



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AGR-3/4 COMPACT 8-4 EXAMINATION PLAN	Identifier: PLN-6225 Revision: 0 Effective Date: 11/12/2020	Page: ii of v

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REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0	11/12/2020	All	New issue.

CONTENTS

TABLE

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 8-4 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 Plan[1] 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 8 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 8-4.

Table 1. Identification and irradiation conditions for AGR-3/4 Compact 8-4.

Compact ID[a]	Container ID	Fabrication ID	Burnup[b] (% FIMA)	Fast Fluence[b] ($\times 10^{25}$ n/m^2)	TAVA (°C)[c]
AGR-3/4 8-4	AGR316	(LEU03-10T-07 DTF)-Z120	14.43	5.02	1169

[a] The X-Y naming convention denotes the location in the irradiation test train—Capsule-Level.[1]
[b] Fissions per initial metal atom (FIMA) and fast neutron fluence (E_n>0.18 MeV) are based on physics calculations.[4]
[c] 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 particles[6]). 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-37[9]. 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

thimble will be subjected to two postburn 24-hour nitric acid leaches in a Soxhlet extractor. After these two postburn leaches, the burned-back particles will be washed, dried, and transferred to a storage vial.

Table 2. Target sectioning dimension for radial deconsolidation.

Compact section	Inner diameter (mm)	Outer diameter[a] (mm)	Section thickness (mm)	Section Volume[b] (cm^3)
Whole compact	0.000	12.126		1.44
1st section	10.501	12.126	0.812	0.36
2nd section	8.574	10.501	0.964	0.36
3rd section	6.063	8.574	1.256	0.36
Core section	0.000	6.063	3.032	0.36

[a] Measured average diameter for irradiated Compact 8-4 was 12.126 mm.[10]
[b] Measured average length used to compute the volume for irradiated Compact 8-4 was 12.5095 mm.[10]

4.2 Data Acquisition, Analysis, and Reporting

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[4] 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 [11] to meet the INL Quality Assurance requirements specified in Inter-Entity Work Order #150293.

6. REFERENCES

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