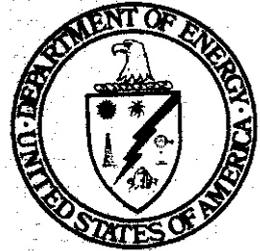


422  
JLS 12-16



---

# Damage Analysis and Fundamental Studies

Quarterly Progress Report  
April - June 1980

---

August 1980

---

**U.S. Department of Energy**  
**Assistant Secretary for Energy Technology**  
**Office of Fusion Energy**  
**Washington, DC 20545**

## CONTENTS

	<u>Page</u>
Foreword	<b>iii</b>
Figures	xi
Tables	xiv
CHAPTER 1. <b>IRRADIATION TEST FACILITIES</b>	1
1. <u>Rotating Target Neutron Source (RTNS)-II Operations (LLNL)</u>	3
 <i>A variety of short term irradiations were performed including studies of NbTi, Cu, and Al at 4K.</i>	
 <i>Facility operation was routine during the quarter.</i>	
 <i>A dosimetry experiment to characterize the neutron field was begun.</i>	
2. <u>Fusion Materials Irradiation Test (FMIT) Facility (HEDL)</u>	5
 <i>Significant reduction of the saturated level of radioactive <sup>7</sup>Be in the FMIT lithium target in order to reduce maintenance problems is difficult to achieve via nuclear means.</i>	
 <i>The FMIT neutron activation file now has over 1080 reactions on 107 nuclides. The NEUACT code system and the pre-equilibrium code PRECO-D are operational both at HEDL and at NMFEEC.</i>	
 <i>Preliminary analysis was completed of neutron spectra and radiation heating from measurements of the transmission of FMIT-like neutrons through thick iron.</i>	

## CONTENTS (Cont'd)

Page

*Analysis of gamma measurements from the thick target Li (d,αγ) reaction at 35 MeV shows a very small gamma yield of low energy gamma rays.*

*FMIT-related nuclear data problems are discussed in a workshop report from the recent Symposium on Nuclear Cross Sections from 10 to 50 MeV.*

**CHAPTER 2.                    DOSIMETRY AND DAMAGE PARAMETERS                    25**

**1.    Fission Reactor Dosimetry (ANL)                    27**

*Radiometric and helium accumulation (RIES) dosimeters have been prepared for the HFIR-T1 irradiations. The status of other dosimetry for irradiations in HFIR, ORR, Omega West, and EBR II is summarized.*

**2.    High-Energy Neutron Dosimetry (ANL)                    30**

*A dosimetry characterization experiment has been conducted at RTNS-11 with RIES and LLL. Plans include mapping the neutron field, measuring helium generation rates, testing nuclear cross section, measuring the room return flux, and cross-calibrating active neutron detectors.*

**3.    Dosimetry Standardization (ANL)                    32**

*Integral cross-section tests are presented for ENDF/B-V and compared to previous results using ENDF/B-IV. The tests are for Be (d,n) spectra measured at  $E_d = 14-40$  MeV.*

CONTENTS (Cont'd)

	<u>Page</u>
4. <u>Helium Generation in Fusion Reactor Materials (RIES)</u>	36

<u>Neutron Fluence Map and Total Helium Generation Cross Section for the 14.8-MeV Neutron Irradiation Environment of RTNS-I</u>	37
---	----

*A detailed neutron fluence map has been constructed for the second Rockwell International irradiation experiment at RTNS-II, and total helium production cross sections have been determined for several pure elements and separated isotopes.*

<u>Characterization of the RTNS-II Neutron Field</u>	45
--	----

*An irradiation experiment has been initiated at RTNS-II to characterize the neutron field, to further develop neutron dosimetry for long-term RTNS-II experiments, and to measure helium generation cross sections of several separated isotopes and pure elements for 14.8-MeV neutrons.*

<u>Helium Production by Be(d,n) Neutrons</u>	45
--	----

*Initial correlations have been made between the neutron fluence and energy spectrum map and the helium generation results for the Rockwell International-ANL-LLL joint Be (d,n) neutron irradiation experiment at the University of California at Davis.*

<u>Helium Accumulation Neutron Dosimetry for Mixed-Spectrum Reactor Irradiations</u>	46
--	----

*Helium accumulation dosimetry materials were supplied to ANL for inclusion in the Omega West Reactor spectral irradiation and the HFIR irradiations HFIR-MFE-T1 and T2.*

CONTENTS (Cont'd)

	<u>Page</u>
5. <u>Displacement Functions for Polyatomic Materials (LASL)</u>	49
<i>Displacement production in diatomic materials having a large mass ratio may be quite different in fission and fusion neutron spectra.</i>	
6. <u>Damage Parameters for Insulators in FMIT (BNL)</u>	55
<i>An uncollided gamma ray flux estimator has been added to the MORSE Monte Carlo transport code.</i>	
<i>The spectrum averaged electronic damage energy cross section has been evaluated for <math>Al_2O_3</math> and <math>Si_3N_4</math>.</i>	
<i>Spectrum average displacement cross sections have been evaluated for <math>MgAl_2O_4</math>.</i>	
7. <u>Simulation of Short-Term Annealing of Displacement Cascades in FCC Metals (HEDL)</u>	60
<i>Computer modeling experiments using calibrated MARLOWE and SCAS codes indicate that the total number of surviving point defects in an <u>isolated</u> cascade produced at any temperature is proportional to the damage energy for cascade energies from 5 keV up to at least 100 keV.</i>	
CHAPTER 3.                   FUNDAMENTAL MECHANICAL BEHAVIOR	73
1. <u>HVEM Observations of Crack Propagation in Helium Irradiated Type 316 Stainless Steel Containing Precipitates (U. Va.)</u>	76
<i>Chi-phase precipitates on grain boundaries in type 316 stainless steel apparently do not serve as crack initiation</i>	

CONTENTS (Cont'd)

		<u>Page</u>
	<i>sites when stressed at 900°C or 25°C. They shear crystallographically and neck down under stress at 900°C in the presence of a high density of helium bubbles at the matrix-precipitate interface.</i>	
CHAPTER 4.	CORRELATION METHODOLOGY	91
1.	<u>Temperature Dependence of Swelling in Single and Dual-Ion Irradiated 316 Stainless Steel (ANL)</u>	93
	<i>In solution annealed and aged MFE 316 stainless steel a broad swelling peak was found for dual-ion irradiated samples, while a smaller and narrower peak was observed for single-ion irradiations of helium preinjected samples.</i>	
2.	<u>Dual-Ion Irradiation of Titanium-Modified 316 SS (W-R&amp;D)</u>	103
	<i>Microstructural evaluation of dual-ion bombarded titanium-modified 316 SS at appm He/dpa ratios of 0.2, 12 and 70 reveals precipitation of MC particles in cube-on-cube orientation with the matrix. Small He bubbles are seen in association with the particles in reasonable agreement with observations on the same material after HFIR irradiation.</i>	
	<i>A first order attempt at partitioning implanted helium between cavities and dislocations results in reduced critical cavity sizes and lower temperature sensitivity for the transition from gas-driven to bias-driven cavity growth.</i>	

CONTENTS (Cont'd)

Page

*A method is proposed for correcting cavity volume fractions and swelling for statistically combined cavity distributions obtained at widely different magnifications, foil thicknesses and cavity sizes.*

3. DAFS Specimen Matrix in the AD-2 Irradiation Experiment (HEDL) 121

*TEM disks of several ferritic alloys, including two pressure vessel steels and several Fe-Ni-Cr alloys, will be irradiated in EBR-II.*

4. HFIR Irradiation of Representative Path B Alloys (HEDL) 126

*TEM disks of ADIP Path B alloys B1, B2, B3, and B4 will be irradiated in HFIR.*