UCID- 17074

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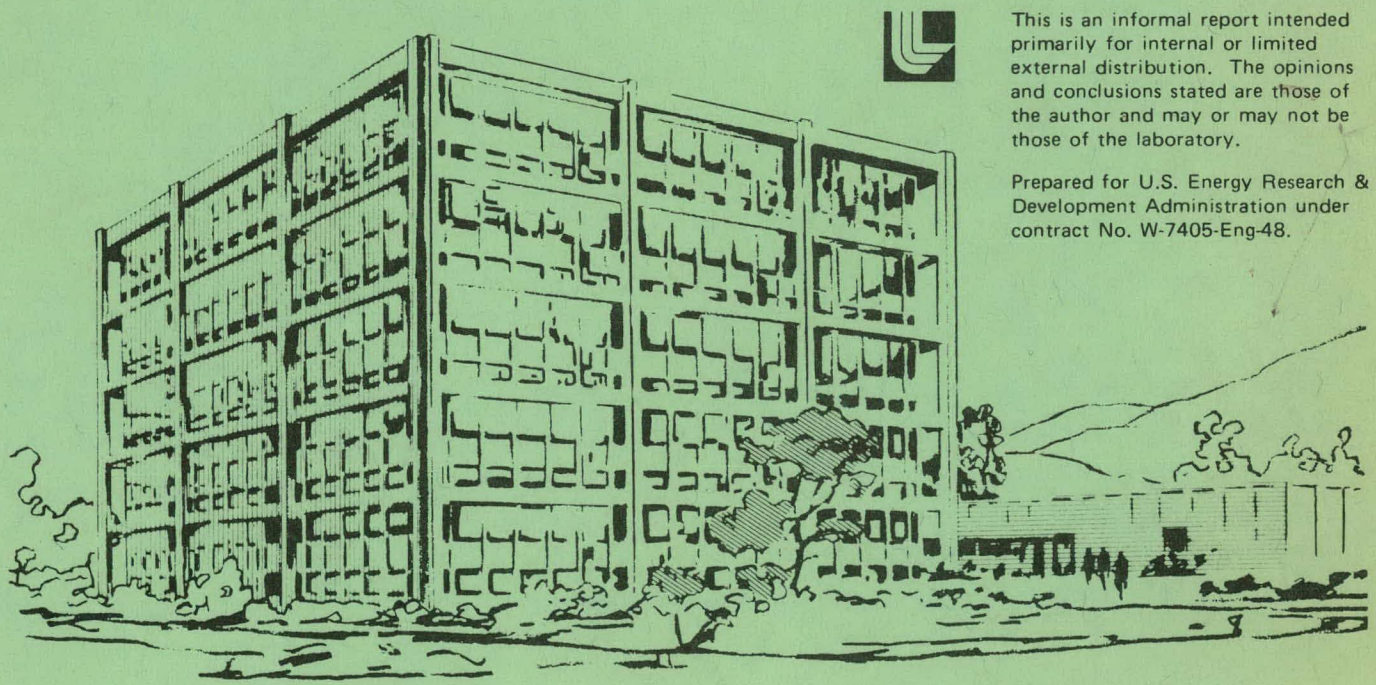
LPTR IRRADIATION OF ORNL MAGNESIUM OXIDE CRYSTALS

Susan C. MacLean and Curtis L. Rowe

November 12, 1975

Unclassified



Prepared for U.S. Energy Research & Development Administration under contract No. W-7405-Eng-48.

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LPTR IRRADIATION OF ORNL MAGNESIUM OXIDE CRYSTALS

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During October, 1975, three magnesium oxide crystals were irradiated in the Livermore Pool Type Reactor (LPTR) for Dr. Yok Chen of Oak Ridge National Laboratory (ORNL).

The LPTR is a 3MW heterogeneous tank-type pool research reactor. It is light water moderated and cooled, beryllium reflected. It has MTR-type fuel elements, composed of aluminum and enriched uranium.

The magnesium oxide samples were irradiated in position E-1 of the reactor core. This position is located at the northwest edge of the core, in the beryllium reflector. The neutron spectrum is, therefore, moderated to a greater degree than in the center of the core. The spectrum has been evaluated by Richard V. Griffith of LLL, using multiple foil activation and iterative computer fitting (UCRL-50007-74-2). The spectrum in the absence of cadmium can be summarized as follows:

Neutron Energy	Flux (n/cm^2-sec)
<0.54 ev	3.39×10^{13}
0.54 ev to 0.1 MeV	1.04×10^{13}
0.1 MeV to 1.0 MeV	8.05×10^{12}
>1.0 MeV	3.95×10^{12}

Dr. Chen requested the following approximate fluences from fission neutrons greater than 1 MeV for his magnesium oxide crystals:

Sample	Fluence (n/cm^2)
MgO	0.7 to 1.0 x 10^{15}
MgO	5 x 10^{16}
MgO	2 x 10^{17}

Each irregular shaped specimen of MgO along with an Fe dosimetry foil (25 mm x 13 mm x 0.25 mm thick) was tightly wrapped in aluminum foil, placed inside a standard aluminum 1100 capsule lined with a 0.5 mm thick cadmium thermal neutron shield. Small wads of aluminum foil were then packed into the remaining voids as heat sinks. The capsule lid was cold welded on by the die and pressure technique, leak checked by placing in a desiccator partially filled with water and evacuated to 28 inches Hg, watching carefully for bubbles.[1]

Calculations indicated that the shape of the neutron spectrum above 0.54 eV should be unchanged to within 4% by the presence of the cadmium. The relative contribution from neutrons of energies below 0.54 eV should be decreased by a factor of about 21.

The reactor water temperature is 40°C, and the sample temperature was estimated to be less than 100°C. The irradiation was carried out by the LLL Radiochemistry Division LPTR operating staff during the period October 10 to 15, 1975. The reactor power was monitored continuously by ionization chambers and particularly by the heat balance across the core. The power was controlled at 3MW ± 5%. The irradiation times were as follows:

Sample	Date	Irradiation Time
MgO-15	October 10, 1975	4 minutes
MgO-16	October 10, 1975	3 hr. 30 minutes

[1] Standard LLL technique for reactor experiments.

MgO-17	October 10, 1975	2 hr. 8 min.
	October 14, 1975	8 hr. 5 min.
	October 15, 1975	3 hr. 41 min.
	MgO-17 total	13 hr. 54 min.

Following the irradiation, the sample cans were stored for several days to allow for decay of short lived isotopes before the magnesium oxide crystals were returned to Dr. Chen at ORNL. The iron dosimetry foils were delivered to Ruth N. Anderson in the LLL Radiochemistry Division for gamma ray counting.

The ^{54}Fe (n,p) ^{54}Mn reaction in iron was used for the dosimetry measurements. The average fluence on each iron dosimetry foil was calculated using the method described in UCRL-51393, Rev. 1. The values used in the calculations were as follows:

Iron sample density - 7.9 gm/cm^3

^{54}Mn half-life - 312.3 days

Iron atomic mass - 55.847 amu

^{54}Fe isotopic abundance - 5.82%

Yield of 835 KeV gamma ray - 100%

t_o was taken as the end of the irradiation period for each sample. Corrections were made for decay assuming a constant flux during the total time the sample was in the reactor, including periods of no power. This introduces a negligible error because of the long half-life of ^{54}Mn. The following spectrum averaged cross sections were used:

$E > 0.54$ eV - 0.0149 barn

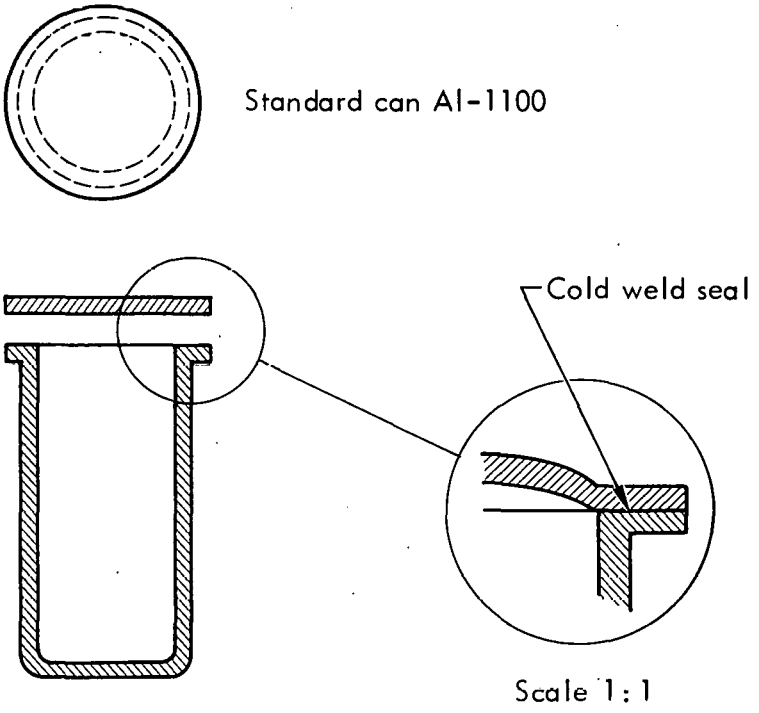
$E > 0.1$ MeV - 0.0275 barn

$E > 1.0$ MeV - 0.0831 barn

These are based upon the spectrum measurements of Griffith, corrected for the cadmium, and upon ^{54}Fe cross section data from the Livermore Evaluated Nuclear Cross Section Library (UCRL-50400, Vol. 4, (1971)). The results were as follows:

		Fluence (neutrons/cm^2)		
Sample	Dosimetry Foil	>1 MeV	>0.1 MeV	>0.54eV
MGO-15	Fe-10	1.11×10^{15}	3.34×10^{15}	6.17×10^{15}
MGO-16	Fe-11	5.55×10^{16}	1.68×10^{17}	3.10×10^{17}
MGO-17	Fe-12	2.23×10^{17}	6.75×10^{17}	1.25×10^{18}

The estimated overall uncertainty of these results is ± 30%. The relative uncertainty between any two values is about ± 2%. The values given here represent average fluences over the volume of each dosimetry foil. The fluences on the MgO samples are expected to correspond closely to these values because of the intimate contact between the foils and samples and the volume nature of the neutron source.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TIC, Oak Ridge, TN, (27)

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy $___*; Microfiche $2.25

*Pages	NTIS Selling Price
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