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EFFECTS OF PILE RADIATION ON BE METAL

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A set of Be metal rods was prepared by casting, extrusion, and machining to a final size $3/16"$ diameter, about $2\frac{1}{2}"$ long. These rod samples were prepared by Dr. A. R. Kaufmann at Massachusetts Institute of Technology, one group of 3 rods being annealed above the recrystallization temperature, the other as cast and extruded.

A series of careful measurements of several properties of these rods was made. The properties measured include length, density, electrical resistivity, frequency of longitudinal vibration, and damping of these mechanical vibrations. Two rods from each group were irradiated in the Hanford 100F pile, between two adjacent heavy metal slugs. The samples were enclosed in an aluminum slug about 4" long. One rod from each group was kept as an unirradiated control specimen. The samples were irradiated and received a total exposure of 50 mrd/ct. The samples were returned to Clinton shortly after discharge, and measurements on them began on March 24.

1. Length. The samples were measured before and after irradiation with micrometer calipers, to a fractional accuracy of $\pm .0002$. The length of each rod did not change by as much as this fraction.
2. Density of the samples was measured by comparison with a standard Be sample, using a flotation method. The liquid used was ethyl iodide, at a temperature near 50°C . This method has a fractional sensitivity of $\pm .00005$. The changes observed are as follows:

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	Ann.		Not Ann.
#5	-.00007	#8	-.00005
#6	-.00002	#9	-.00005
Unirradiated #7 (control) -.00003			

The changes are all less than the estimated precision of the measurement, but are all in the same direction. All that can be said is that the density may be decreasing very slightly, but that for 50 mmd/ct exposure, it is not more than -.00005 fractional change.

3. The electrical resistivity was measured using a potential difference method. The current through the sample is measured by observing, with a Type K₂ potentiometer, the p.d. across a standard 0.1 ohm resistor. The p.d. across the sample is measured with the same instrument, and errors due to thermal and contact emfs are minimized by reversal procedures. The sample is thermostated in an oil bath near 25°C, to $\pm 0.1^\circ\text{C}$. The resistivity can be measured to a fractional accuracy of $\pm .004$, and to this precision no change in resistivity of Be was observed.
4. The frequency of elastic vibrations was measured by the composite piezo-electric oscillator method previously used on the project for other similar studies. The frequencies of these rods is in the neighborhood of 107 kc. These frequencies measurements are reproducible on the unirradiated controls to a fractional accuracy of $\pm .0003$.

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Sample #	Original	After 50 mwd/ct	Diff
5	108056 cycles	108041 cycles	-15 cycles
6	108130	108117	-13
7 (control)	108208	108165	-43
8	108266	108250	-16
9	108106	108090	-16

To the precision with which these measurements are made, no change in resonance frequency has been produced by a 50 mwd/ct exposure.

5. The damping of these mechanical vibrations is determined by measuring the equivalent electrical resistance at resonance of the vibrating mechanical system. This resistance is proportional to the energy dissipated per cycle of vibration and hence to $(1/Q)$ for the system. This method of measuring the damping is sensitive to small changes under the best conditions, but under the conditions of this experiment, damping values on a single specimen are reproducible to about $\pm .10$. The results are

	R originally	R after 50 mwd/ct
#5	16000 ohms	23400
#6	17000	12500
#7 (Control)	14000	15000
#8	11500	10500
#9	16800	19000

Although the changes in some of the rods are greater than the estimated precision, it appears valid to conclude that no significant change in the damping has occurred.

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6. After the measurements described above were completed, the hardness of these samples was measured on the Rockwell superficial hardness tester, using the 30-T scale, a load of 30 kg. on a 1/16" ball. The results are given below, and indicate that no change in hardness occurred:

#5	#6	#7 (Control)	#8	#9
48.5 $\pm$ 1.5	52.0 $\pm$ 1.0	47.8 $\pm$ 3	50.8 $\pm$ 1	49.7 $\pm$ 1

7. The thermal conductivity of the samples after irradiation was compared with that for the unirradiated controls. No significant change was found; these measurements are valid to $\pm .05$.
8. The conclusion to be reached is that 50 mrd/ct irradiation to fast neutron flux in Hanford at temperatures near 30°C, followed by a waiting period of about 1 week at normal temperatures, produces no measurable change in the properties of Be metal.
9. Radioactivity. The activity level was sufficiently low that relatively simple techniques were adequate for handling the samples. When they were first retrieved on March 24, after discharge on March 16, the activity of a single sample, as observed with a health physics instrument at 3", was 200 mr/hr. A considerable portion of this activity was due to beta particles. The intensity of hard gamma radiation penetrating 1/2" of lead, as observed with a thin window counter at 10", was 0.35 mr/hr.

Analysis of the absorption of the gamma radiation in lead indicated the presence of two components in comparable amounts, having energies of

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approximately 0.3 mev and 1.4 mev respectively.

The decay of the hard gamma component was followed for about two months. During this period the decay could be represented approximately as due to two components with half-lives of 6 days and 57 days respectively.

A rough estimate of the intensity of the hard gamma radiation to be expected from metal irradiated for several weeks may be obtained from the following formula:

$$I = \frac{w M}{T} \left[0.18 \exp (-0.116t) + 0.0048 T \exp (-0.0122t) \right]$$

Where

I = mr per hr at 10 inches

w = weight of metal in grams

M = amount of irradiation in megawatt days per central ton

T = duration of irradiation in days

t = time after discharge from pile in days.

The experimental tests reported here were carried out in part with the assistance of D. Billington, H. S. MacPherson and R. P. Metcalf.

END

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