BNWL-682

2-

ELEVATED TEMPERATURE
HARDNESS TESTING
OF PLUTONIUM-GALLIUM ALLOYS

D. D. Hays

March 1968

AEC RESEARCH &
DEVELOPMENT REPORT

ROUTE TO	P.R. NO.	COPIES	FILED ROUTE DATE

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

operated by

BATTELLE MEMORIAL INSTITUTE

for the

UNITED STATES ATOMIC ENERGY COMMISSION UNDER CONTRACT AT(45-1)-1830

PRINTED BY/ FOR THE U. S. ATOMIC ENERGY COMMISSION

3 3679 00061 0933

BNWL-682
UC-25, Metals, Ceramics
and Materials

ELEVATED TEMPERATURE
HARDNESS TESTING
OF PLUTONIUM-GALLIUM ALLOYS

By

D. D. Hays

Plutonium Development Section
Metallurgy Department

March 1968

FIRST UNRESTRICTED
DISTRIBUTION MADE

MAR 18 '68

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

Printed in the United States of America
Available from
Clearinghouse for Federal Scientific and Technical Information
National Bureau of Standards, U. S. Department of Commerce
Springfield, Virginia 22151
Price: Printed Copy \$3.00; Microfiche \$0.65

ELEVATED TEMPERATURE HARDNESS TESTING OF PLUTONIUM-GALLIUM ALLOYS

D. D. Hays

INTRODUCTION

This report describes the hardness testing of plutonium-1 wt% gallium alloys between room temperature and 415 °C. Small amounts of gallium added to plutonium stabilize the face-centered, cubic delta-phase to room temperature, thereby improving working characteristics of the alloy through increased ductility. This study was made to fill a gap in the mechanical property data of these alloys.

EQUIPMENT AND PROCEDURE

The indentations were made with a hardness tester built by the Marshall Products Company, Columbus, Ohio. A schematic of this equipment is shown in Figure 1. Before testing, the lever arm is balanced horizontally with the adjustable counterweight, and the pedestal height is adjusted so that the sample surface is 1/4 in. below the indenter. The indenting load is obtained by placing weights on the weight pan. A 4:1 ratio exists between the indenting weight load and the weight on the pan. A variable speed motor is used for different loading rates and indenting times. Offsetting of the indenter column 1/2 in. from the vertical axis of the pedestal enables several different areas of the specimen to be positioned under the indenter by rotating the pedestal.

Because the hardness tester was designed for refractory-type materials requiring 2 to 10 kg indenting loads at 1000 to 2000 °C, its use for such relatively soft, low melting materials as delta-stabilized plutonium was limited. A sample of delta-stabilized plutonium of known hardness was used to calibrate the hardness tester at room temperature. Several indentations were made with a 136 °C pyramid sapphire indenter,

FIGURE 1. Schematic of Marshall Products Co.
Elevated Temperature Hardness Tester

and the diagonals measured on a standard Tukon hardness tester. The lowest indenting load that would provide correct, reproducible results was 578 grams. This load corresponds to a pan weight of 144.5 grams.

The alloy was heat treated for 150 hr at 450 °C to obtain complete homogenization. The ends of the samples were machined parallel and the test surface was polished metallographically. The samples were heated to temperature in vacuo and 3 indentations were made at each temperature.

RESULTS AND DISCUSSION

The effect of temperature on the hardness of Pu-1 wt% Ga alloys is shown in Table I. A graph of these data, Figure 2, yields a smooth curve to about 325 °C. The last two data points, at 385 and 415 °C, are considerably lower than would be expected by extrapolating the curve in Figure 2. Starting at about 325 °C, the creep stress of the Pu-Ga alloys is apparently low enough so that creep occurs under the indenter during the hardness test. The effect of creep is to lower the measured hardness. As the test temperature is increased, the creep stress is lowered and the effect of creep becomes progressively larger. The effect of creep was minimized in all tests by reducing the loading and indenting time to 15 sec, the minimum obtainable with this equipment. Nevertheless, hardness values for temperatures above 323 °C should be regarded with suspicion since they have probably been significantly lowered by creep.

TABLE I. *Temperature Versus Hardness for Homogenized Pu-1 wt% Alloys*

<u>Temperature, °C</u>	<u>Hardness, kg/mm³</u>
25	40.5
121	30.8
172	26.0
196	23.6
254	19.5
323	14.5
385	5
415	3

FIGURE 2. Diamond Pyramid Hardness Versus Temperature for Homogenized Plutonium-1 wt% Gallium Alloy

DISTRIBUTIONNo. of
Copies

2	<u>AEC Albuquerque Operations Office</u> D. Johnston Lt. Col. D. Overton
2	<u>AEC Chicago Patent Group</u> G. H. Lee R. K. Sharp, Richland
2	<u>AEC Richland Operations Office</u> C. L. Robinson J. L. Rhoades
5	<u>AEC Division of Technical Information Extension</u>
1	<u>AEC Library, Washington, D.C.</u> <u>Division of Military Application</u> Col. I. L. Williams
2	<u>Dow Chemical Company</u> <u>Rocky Flats Division</u> R. D. Forest J. E. Pavlick
8	<u>Lawrence Radiation Laboratory</u> <u>Livermore, California</u> J. Hadley C. R. Henry J. O. Jepson M. D. Martin W. M. Miller/D. E. Loewe H. N. Perl W. J. Ramsey J. L. Robbins
2	<u>Los Alamos Scientific Laboratories</u> R. D. Baker F. W. Schonfeld

No. of
Copies

29

Battelle-Northwest

V. C. Asmund
R. A. Busch
J. J. Cadwell
S. D. Dahlgren
R. E. Falkoski
H. R. Gardner
G. P. Hanneman
W. S. Hartnett
D. D. Hays
Y. B. Katayama
R. R. King, Jr.
E. D. McClanahan
R. W. Moss
R. D. Nelson
C. S. Powers
J. C. Spanner
R. W. Stewart
J. M. Taylor
W. B. Weihermiller
O. J. Wick
300 Files (3)
Technical Information Files (5)
Technical Publications