UCRL-7771

CONF-640416-1

MASTER

University of California

Ernest O. Lawrence
Radiation Laboratory

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

MECHANICAL PROPERTIES OF SOME URANIUM ALLOYS

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

Livermore, California

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Livermore, California

Contract No. W-7405-eng-48

MECHANICAL PROPERTIES OF SOME URANIUM ALLOYS

C. A. W. Peterson
R. R. Vandervoort

March 18, 1964

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

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.

MECHANICAL PROPERTIES OF SOME URANIUM ALLOYS

C. A. W. Peterson and R. R. Vandervoort

Lawrence Radiation Laboratory, University of California
Livermore, California

March 18, 1964

INTRODUCTION

This is a summary of mechanical properties of some high-strength, gamma-phase, uranium-base alloys. The alloying elements are Mo, Nb, and Zr, which are known to be stabilizers of the body-centered-cubic phase of uranium.

The alloys were prepared by arc melting, in an argon atmosphere, consumable electrodes made up of strips of the component metals. The principal interstitial impurity, carbon, was kept below 100 ppm. Ingots were conditioned by hot forging and wrought to plate by hot rolling. All tensile blanks were gamma-annealed and quenched prior to machining samples for testing. Isothermal heat treatments were performed on the samples of each alloy before testing. Time-temperature-transformation data were determined during the heat treatment, and these data will be published later.

SUMMARY AND MECHANICAL PROPERTIES

The room-temperature tensile properties of the alloys, as annealed at 800°C for 1 hour and water quenched, are summarized in Table I.

The results of a few elevated temperature tests of the gamma-annealed uranium alloys are given in Table II. All specimens were rapidly heated to test temperature by their electrical resistance.

Table I. Room-temperature tensile properties of gamma-annealed alloys.

Alloy Composition						Strain rate, $\dot{\epsilon}$, in./in./min	Yield strength 0.2% offset psi $\times 10^{-3}$	U.T.S. psi $\times 10^{-3}$	Elong. %	ϵ psi $\times 10^{-6}$
w/o			a/o							
Mo	Nb	Zr	Mo	Nb	Zr					
10	-	-	21.6	-	-	0.05	122	127	16.0	20-22
-	10	-	-	21.7	-	0.05	120	170	12.0	(15)
-	-	5	-	-	12.1	0.05	170	234	5.0	19
-	7.5	2.5	-	16.7	5.6	0.05	100	150	12.3	15
5	5	5	10	10.4	10.6	0.05	120	175	15.0	(11)
-	10	1	-	21.3	2.2	0.05	164	165	13.0	--
*-	-	-	-	-	-	0.05	35	110	25.0	22-28

*Unalloyed Uranium

Table II. Elevated temperature tensile properties of gamma-annealed alloys.

Alloy composition			$\dot{\epsilon}$ in./in./sec	Ultimate tensile strength psi $\times 10^{-3}$		% Elongation	
Mo	Nb	Zr		800°C	600°C	800°C	600°C
10	-		0.001	16	47	53	11
			0.01	30	55	39	3.5
			0.10	33	58	37	11
-	7.5	2.5	0.0005	9.5	24	60	22
			0.10	17.0	33	60	16
Uranium			0.001	-	6.3	-	43
			0.01	-	8.4	-	36
			0.1	-	8.9	-	57

Isothermal heat treatment for 8 hours at 500°C, at the "nose" of the T-T-T curve for each of the alloys, produces the changes in the room temperature tensile properties given in Table III. For the Nb-Zr alloys 350°C was the heat-treatment temperature; these properties denoted by asterisk.

The diamond pyramid hardness and Charpy V-notch impact values for the gamma-quenched and 500°C isothermally aged alloys are shown in Table IV.

Table III. Tensile properties of gamma-annealed uranium alloys after isothermal heat treatment.

Alloy composition w/o			Yield strength psi $\times 10^{-3}$	U. T. S. psi $\times 10^{-3}$	% Elongation
Mo	Nb	Zr			
10	-	-	123	127	15
-	10	-	145	186	1.0
-	-	5	130	190	7.0
-	7.5	2.5	*190	*245	* 3.5
-	10	1	*242	*243	* 4.0

Table IV. D. P. N. hardness and Charpy impact values for uranium-base alloys.

Alloy Composition w/o			Gamma quenched from 800°C		Isothermally aged 500°C 8 hours	
Mo	Nb	Zr	D. P. N.	Charpy (ft-lbs)	D. P. N.	Charpy (ft-lbs)
10	-	-	280	7-10	310	6-7
-	10	-	255	7	530	-
-	-	5	475	5.5	450	-
-	7.5	2.5	205	19-22	390	10
5	5	5	335	7.5	345	-

In order to further evaluate the toughness of these alloys, impact tests were carried out on modified Charpy bars in the temperature range -40°C to 100°C. Duplicate tests were conducted at -40°C, 0°C, 25°C, and 100°C after the specimens had been vacuum annealed (10^{-5} mm Hg) for 1 hour at 800°C and quenched. Where the availability of specimens permitted, impact strengths were obtained for the "as received" material. For these the final treatment had been a salt-bath anneal at 750°C followed by a slow cool. Results are plotted in Fig. 1. The interstitial analyses are given in Table V.

Fig. 1. Impact strength of uranium-base alloys in the as-received and vacuum-annealed states.

Table V. Interstitial content for impact specimens.

Alloy	Condition	Interstitial			
		H	O	N	C
		ppm	ppm	ppm	ppm
10 Mo	As received	7	8	13	40
10 Mo	Vacuum anneal	3	8	16	38
10 Nb	As received	23	38	54	33
10 Nb	Vacuum anneal	4	38	66	53
7.5 Nb - 2.5 Zr	As received	20	43	26	43
7.5 Nb - 2.5 Zr	Vacuum anneal	4	38	32	56

Welding tests were conducted by tungsten-inert-gas fusion butt joining 0.250-in. -thick plates of gamma-annealed alloys in an argon atmosphere.

The 10 w/o molybdenum alloy welds cracked unless immediately post-heated to a temperature of 275 to 300°C. Welding of the other alloys produced no major difficulties and went very smoothly. There was no tendency to post-weld cracking of either weld or plate. Postheating the niobium-zirconium alloy had a strengthening effect on the weld. The tensile properties of some of the alloy welds are summarized in Table VI.

Table VI. Tensile properties of uranium alloy TIG welds.

Alloy composition			Heat treatment	Yield strength psi	U. T. S. psi	% Elong.
Mo	w/o Nb	Zr				
10	-	-	Postheat 275°C 1/2 hour	140,000	145,000	6
-	10	-	none	125,000	165,000	7
-	-	5	none	165,000	203,000	3.5
-	7.5	2.5	none	130,000	136,500	11
-	7.5	2.5	Postheat 275°C 1/2 hour	139,500	152,000	6

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.