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TECHNICAL INFORMATION MEMORANDUM

SUBJECT: A Program to Study the Effects of Neutron
Irradiation Upon Columbium Base Alloys

TIM NO. 813, Sup. 1, Rev. 1

DATE OF REPORT: June 17, 1964

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	<u>HFC</u>	<u>U</u>	<u>12/26/61</u>
	<u>RCD</u>	<u>U</u>	<u>05/02/62</u>

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Introduction

On March 12, 1964, a memorandum was written encompassing all aspects of a program designed to determine neutron irradiation effects upon physical properties and microstructure of columbium base alloys. In the initial phase of this program, electron beam melted Cb-1Zr and Cb-1Zr-0.1C (PWC-11) alloys were to be subjected to tensile testing and microexamination in the irradiated and unirradiated condition to provide the following information:

1. The effect of neutron irradiation on yield point, ultimate tensile strength, and elongation.
2. The extent of hardening produced by the irradiation.
3. The relationship of annealing conditions on extent and rate of recovery.
4. Interrelationship between the strength hardness, and structural characteristics of both alloys.

Materials to be Tested

Two materials will be tested: Cb-1Zr-0.1C (PWC-11) and Cb-1Zr.

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The PWC-11 alloy (Heat Code GC-62) was cast as a 4 inch ingot and extruded at a 4/1 reduction ratio at 1600C (2900F). After cleanup, it was annealed for one half hour at 1315C (2400F) and press forged in the Bliss Press to 0.750 inch thickness. The surfaces were then machined and the material was heat treated for one hour at 1315C (2400F) before cold rolling to 0.05 inch sheet.

The Cb-1Zr alloy (Heat Code PIFT) was melted by DuPont into an 8 inch ingot, cold extruded to one inch bar, cold forged to one half inch sheet, annealed two hours at 1205C (2200F) and cold rolled to 0.05 inch sheet. Subsequent heat treatments for both materials will be described in the accompanying flow sheets.

Experimental Test Conditions

The specimens are to be irradiated in the Battelle Research Reactor to an integrated fast neutron dose of $1-2 \times 10^{19}$ neutrons per cm^2 greater than 1 Mev. A cadmium shield is to be utilized and the specimen temperature is to be kept below 100C (210F) if possible. The specimens are to be run in NaK for purposes of heat dissipation and design simplification. Previous data indicate that no contamination will occur on any of the materials at 100C. The NaK is not to be used for compatibility evaluations.

The flow charts for the Cb-1Zr and PWC-11 alloys accompany this report and supersede those given in TIM-813. All irradiated specimens will be run in triplicate and the unirradiated control specimens in duplicate. The specimens to be irradiated include:

A. Tensile specimens - 50 mils thick, 2 3/4 inches long, 3/8 inch wide

1. PWC-11 - 60
2. Cb-1Zr - 18

B. Hardness and Thin Film Specimens

1. PWC-11 - 140, 50 mils thick, 1/2 inch long, 1/4 inch wide
2. Cb-1Zr - 100, 50 mils thick, 1/2 inch long, 1/4 inch wide

NOTE: Although a large number of hardness and thinfilm tabs will be irradiated, only an adequate number will be examined in order to obtain sufficient data.

The PWC-11 specimens will weigh 650 grams and the Cb-1Zr specimens 300 grams. Total weight of all specimens to be irradiated will be 950 grams.

Time Schedule

The estimated time for completion of portions of the program are the same as those listed in TIM-813, Sup. 1.

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Flow Chart A

- Objectives:
1. To provide materials data to assist in post irradiation evaluation of engineering tests.
 2. To determine the need for an immediate impile creep test program.

Accomplished By: Tensile Tests
Hardness
Electrical Resistivity
Metallography

Cb-1Zr and PWC-11 Tensile Specimens

Heat Treatment

HT 1 Hr @ 1260C (2300F)

Anneal

HT 2 Hr @ 1205C (2200F)

Irradiate

1-2 x 10¹⁹ nvt
>1 Mev, <100C (210F)

Tensile Test in the Following Conditions

Post Irradiation Evaluation:

As Irradiated

Tensile Testing

HT 1 Hr @ 200C (390F)

Hardness Measurements

HT 1 Hr @ 300C (570F)

Resistance Measurements

HT 1 Hr @ 500C (930F)

Optical and Electron
Metallography

HT 1 Hr @ 700C (1290F)

HT 1 Hr @ 1000C (1830F)

1. After the indicated post irradiation anneals, the specimens will be tensile tested at room temperature at a constant strain rate of 0.01 in/in/min.
2. Several irradiated and irradiated plus annealed specimens will be analyzed for carbon and oxygen to make certain that changes in strength have not been caused by interstitial contamination during heat treatment.
3. HT refers to heat treat.

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Flow Chart B

- Objectives:
1. To provide materials data to assist in post irradiation evaluation of engineering tests.
 2. To determine the need for an immediate impile creep test program.

Accomplished By: Tensile Tests
 Hardness
 Electrical Resistivity
 Metallography

PWC-11 (Cb-1Zr-0.1C) Tensile Specimens

1. After the indicated post irradiation anneals, the specimens will be tensile tested at room temperature at a constant strain rate of 0.01 in/in/min.
2. Several irradiated and irradiated plus annealed specimens will be analyzed for carbon and oxygen to make certain that changes in strength have not been caused by interstitial contamination during heat treatment.
3. HT refers to heat treat.

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