APPENDIX D

PUBLISHED REPORTS & EXCERPTS

AUTHORED BY

(copies of files on CDRoM)

1979 USAF Alloy Development F0835-79-C-0267

1980 US Army Recycle Program DAAK10-80-C-0246

Foam Encapsulation

NMI Views Article

Depleted Uranium Test Range Fragment Reclamation F08635-82-C-0100
Storming Media Abstract, Final Report for work performed between 81 – 82

3. DU-8 W/O Mo ALLOY

This alloy is also a gamma stabilized alloy with a potential for use as a liner material.

Melt UX0027 was cast for this program; however, the carbon content was higher than was desirable. Melting procedures and chemical analysis are shown in Table 3 for this alloy. Melt UX1043 was cast for another program at the Contractor's facility. The carbon content was significantly lower for Melt UX1043 than that for UX0027. Sufficient material for both programs was available from Melt UX1043, so it was decided to proceed with this lower carbon alloy. Additional trace element analysis of Melt UX1043 is given in Table 4.

The processing sequence for the DU-8Mo alloy was essentially identical to that used for the DU-6.5Nb alloy. The DU-8Mo was cast into a 4 1/4 inch diameter mold. This billet was machined into slugs of 3 1/2-inch diameter by 3 1/2-inch length. The remainder of the processing follows the same path as described for the DU-6.5Nb alloy and the general process flow chart presented in Figure 1.

4. DU-0.75 W/O Ti ALLOY

Excellent ductility has been achieved with this alloy during the past few years as a result of improved chemistry and heat treatment studies aimed at improving the toughness of this material for withstanding firing forces placed on kinetic energy projectiles.

The alloy was obtained from material prepared for the Army's M774 KE projectile production. There is a tight chemical specification for low carbon, iron, and hydrogen in this material. Table 5 shows the standard melting and casting conditions for this alloy as well as the chemistry of Lot 92, Billet 9, from which material for test specimens and liners was obtained.

The billet was 4 1/2 inches in diameter by 20 inches long. Two slugs from the bottom of the billet were machined to a 3 1/2-inch diameter by 3 1/2-inch length. The slugs were then processed according to the general flow chart of Figure 1 and the same conditions used for the DU-6.5Nb alloy previously described.

F0835-79-C-0267

AFATL-TR-80-117

DEPLETED URANIUM ALLOYS FOR USE IN CONVENTIONAL WARHEADS

October 1980

Final Report for Period August 1979 - September 1980

Distribution limited to U.S. Government agencies only; this report documents test and evaluation; distribution limitation applied October 1980. Other requests for this document must be referred to the Air Force Armament Laboratory (DLJW), Eglin Air Force Base, Florida 32542.

Prepared for

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SECTION I

INTRODUCTION

1. OBJECTIVE OF THE PROGRAM

The objective of the efforts described in this report has been to evaluate depleted uranium (DU) and several DU alloys for application to shaped charge warheads. Since dynamic ductility of the material is an important property affecting warhead performance, attempts were made to apply fabrication techniques using equipment available at the contractor's facility to optimize these properties. If test firings of warheads fabricated from these materials are successful, commercially available DU would be immediately available to meet Air Force needs for a high density SFF warhead. If test firings are unsuccessful or inconclusive, further efforts would be needed to establish the minimum DU material requirements for successful warhead performance.

2. SCOPE OF THE RESEARCH AND DEVELOPMENT PROGRAM

The scope was originally established as a 10-month effort to examine the application of several DU candidate materials for shaped charge warheads. The prime contractor was responsible for material selection, heat treatment, warm working, production and static material property testing. Dynamic properties data were obtained by Bill Cook of the Air Force Armament Laboratory from Taylor Anvil specimens produced at the contractor's facility and test fired at Denver Research Institute (DRI). Warhead firing fixtures of steel and plexiglass and DU liners of 4 different materials were fabricated according to designs supplied by the Air Force.

Loading and test firing of the shaped charge warheads are being performed by the Los Alamos Scientific Laboratories (LASL). Test analysis and firing data will be supplied by LASL.

SECTION II

FABRICATION PROCEDURES

1. DU-6.5 W/O (Weight Percent) Nb ALLOY

This material was examined as a candidate liner material for several reasons. Previous experience with a cross-rolled, fine grained DU-6.5Nb plate had shown the plate to have substantial ductility (38 percent elongation) with a grain size of American Society of Testing and Materials (ASTM) 6 to 6 1/2. As a gamma stabilized alloy at room temperature, it has a body centered cubic structure with more slip systems than a DU alloy of orthorhombic structure in the alpha phase.

An attempt was made to directly vacuum melt and cast this alloy and work the material in order to obtain a fine grain structure. Three castings were made of 2 billets each. The billets were of 3 3/4-inch diameter by 20-inch length and weighed approximately 150 pounds each.

The chemical analysis and melting conditions used for these attempts are shown in Table 1. Niobium plate had been used with success in previous niobium alloy melts, and it was felt that by increasing the surface area of the niobium, the material would more rapidly alloy with uranium. The objective was a lower superheat temperature and shorter length of time at temperature in order to obtain a lower carbon content. In all attempts, unalloyed virgin derby with low carbon, 10 to 40 parts per million (ppm), was selected for alloying.

The niobium shot used in Melt UX9691 remained at the bottom of the crucible where it was initially placed. The niobium never floated and was observed as part of the crucible skull after the molten alloy was poured. A low niobium content was the net result.

Milled niobium chips were used on the second attempt in Melt UX9764. These floated to the top of the molten DU, partially sintered, and did not alloy completely.

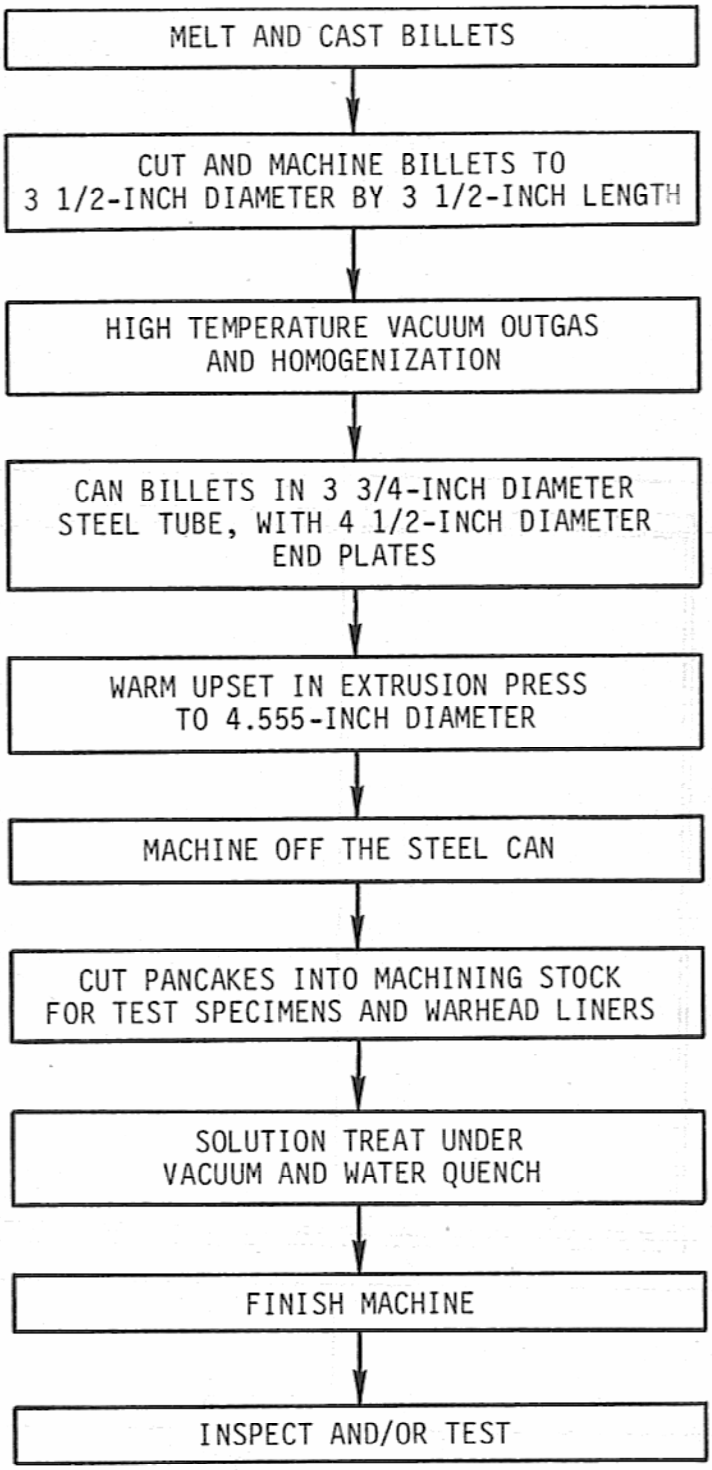

Figure 1. General Process Flow Chart for DU-6.5Nb, DU-8Mo and DU-3/4Ti Alloys

AFATL-TR-80-117

Depleted Uranium Alloys For Use In Conventional Warheads

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FINAL REPORT FOR PERIOD AUGUST 1979-SEPTEMBER 1980

Air Force Armament Laboratory
AIR FORCE SYSTEMS COMMAND ★ UNITED STATES AIR FORCE ★ EGLIN AIR FORCE BASE, FLORIDA