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**THIN-METAL ENCAPSULATION OF FISSION FOILS AND OXIDE DISCS
BY RESISTANCE WELDING***

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THIN METAL ENCAPSULATION OF FISSION FOILS AND OXIDE DISCS BY RESISTANCE WELDING*

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The Interlaboratory LMFBR Reaction Rate (ILRR) Program was established in 1971 by the U. S. Atomic Energy Commission, Division of Reactor Research and Development. The objective of this program was the development of the capability to precisely measure neutron-induced reaction rates of LMFBR fuels and related materials.

The Isotope Research Materials Laboratory of the Oak Ridge National Laboratory has been actively involved in development and fabrication of various types of dosimeters to meet the demands of this program since its inception.

One type of dosimeter utilized in this program has been thin metallic and oxide discs of uranium, plutonium, and neptunium isotopes. Because of the extreme reactivity and radiotoxicity of these materials, it has been necessary to fabricate these dosimeters with a welded closure.

The stringent dimensional specifications and the extreme thinness of the container materials precluded the use of conventional welding techniques. This report describes the equipment and procedures employed to attain the welded closures required to hermetically seal these thin metal containers.

1. Introduction

The Interlaboratory LMFBR Reaction Rate (ILRR) program was established in 1971 by the U. S. Atomic Energy Commission, Division of Reactor Research and Development. The objective of this program was to formalize the precise measurement of neutron-induced reaction rates of

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LMFBR fuels and dosimeter materials. Data acquired from this program has allowed very accurate neutron flux mapping of reactor cores. The Isotope Research Materials Laboratory (IRML) has been actively involved in the development, fabrication, and characterization of various forms of dosimeter materials to meet the demands of this program since its inception.

One type of dosimeter utilized in this endeavor is a thin fission foil disc of either metal or densified oxide of uranium, plutonium, or neptunium. Because these elements are extremely reactive and have high radiotoxicity, it has been necessary to hermetically encapsulate these materials with a welded closure. The requirement for stringent dimensional specifications and very thin metal containers (0.125-0.180 mm.) precluded conventional welding techniques.

This paper describes the equipment and techniques employed to perform the peripheral closures required to seal these very thin metal containers. Although the welding described herein was developed for the encapsulation of dosimeter materials, the method would be equally applicable to other thin metal joining requirements.

2. Equipment

2.1. Welding Jigs and Fixtures

The welding equipment (Fig. 1) consists of three major components. First, the frame of the welding apparatus is machined from steel and then nickel plated to prevent surface oxidation; it retains and aligns all other parts and serves as an electrical ground during welding.

Two electrodes constitute the second major component of the assembly, and these are constructed of cemented tungsten carbide and are dimensionally ground to precise tolerances. The ends of both electrodes are bored to a depth of 2.86 cm to accommodate an alundum retainer plug and compression spring. The retainer in the top electrode is held in place by a through-pin which allows vertical movement of the retainer. The lower electrode is radially adjustable to align with the upper electrode and is held in position by the bottom guide, thus providing electrical contact with the frame. The upper electrode is radially fixed, but moves vertically through the insulating bushing which permits easier loading of capsule components. The upper electrode serves as the positive electrical contact and transmits pressure to the metal container components during welding.

Finally, the combination guide and shear is machine-ground from hardened tool steel. The bore of the guide is a precise fit to the exterior of the welding electrodes. During loading of capsule components it serves as a guide to locate the two halves of the metal container and to align the upper and lower electrodes. The bottom edge of the guide serves also as a shearing surface to cut the welded containers to precise diameter.

2.2. Auxiliary Equipment

A commercial spot-welding power supply (Fig. 2) was used for electrical power. The power supply consists of an Entron absolute binary count control coupled to a 90-kVA stepdown transformer (water cooled), having a secondary voltage range of 5.3-7.1 volts. Power is conveyed from the source to the welding fixture through conventional welding

cables. This equipment provides very flexible control of delivered power and weld duration.

A commercial hydraulic (Figs. 4 and 5) cylinder was utilized to provide pressure to the welding electrodes and to position the upper electrode during loading of capsule components. A loading guide (Fig. 3) was used to locate the fission foils in the center of the bottom half of the capsule.

Where material reactivity and radioactivity was of concern, welding was performed in an argon atmosphere. A commercial glove box was used to provide the inert atmosphere and to contain the radioactive species.

2.3. Welding Conditions

The joining of two metal objects by the diffusion of surface molecules is a function of heat, pressure, and time. With metals having surface oxidation (particularly aluminum), this diffusion is greatly enhanced by a lateral displacement of the metal in both phases being bonded. As the metal is caused to move by the application of heat and pressure, surface oxide particles are dispersed in the metal phases allowing the metal components to form a hermetic bond.¹

Welding conditions were determined experimentally which would result in leak-free bonds using either pure copper or aluminum (0.125-0.180 mm thick) without excessive loss of metal by extrusion out of weld zone. Typical welded areas retained a metal thickness of 0.125-0.26 mm. A pressure of 241-317 MPa (35,000 to 46,000 psi) was applied to the weld area while a total of 17.4 kW-seconds of power was applied to heat the

metal interface by resistance. Both pressure and power requirements are varied depending upon metal type and thickness. Single and double encapsulation welds are illustrated at various stages of completion (Fig. 7). The hydro-forming die assembly used to shape the capsule parts is also shown (lower right):

3. Procedure

The sequence of operations for performing a weld is begun with all components in the loading position (Fig. 3). The bottom container half is placed in the guide, dished side up. The tapered loading guide is inserted on top of the container half and the fission foil located at the center of the container recess. The loading guide is removed and the top half of the capsule is inserted, dished side down. The upper electrode is forced down to contact the two container halves. At this point the fission foil and two capsule halves are clamped together by the two electrodes and the guide-shear is moved to the aligning position shown in Fig. 3. The positive electrical contact plate is inserted between the top electrode head and the hydraulic cylinder ram. A 2224 N (500-lb.) force is applied to hold all components in alignment. The guide-shear is then raised onto the upper electrode and held in the welding position (Fig. 3) by a rubber "O" ring. A 17,790-22,240 N (4000 to 5000 lb.) force is applied to the upper electrode and the two container halves are bonded together by the application of the appropriate amount of power. After cooling, the force on the upper electrode is lowered to 2224 N (500 lb.) and the guide-shear is moved downward forcefully to cut off the slight

amount of container metal extruded during welding (Fig. 3). The upper electrode is then raised for removal of the welded container and subsequent reloading.

4. Results

Several hundred dosimeters of this type, containing either a metal foil or a densified oxide disc, have been successfully welded using this technique. All copper or aluminum containers were leak checked by immersion in ethylene glycol under vacuum and a rejection rate of less than one percent was achieved. Detection sensitivity of this leak test is considered to be 10^{-4} cc/min. helium. Completed dosimeters are normally radiographed to ascertain concentricity of the sample discs inside the containers. Six typical ^{239}Pu dosimeters (in aluminum) are shown as radiographed (Fig. 6).

5. Conclusion

Hermetic encapsulations of metal or oxide samples of actinide elements can be easily performed by diffusion bonding of thin metal shells. Use of hydraulic pressure and heat generated by electric current resistance rapidly forms the circular (in this case) bond. Double encapsulation can be performed using concentric capsules sealed sequentially. Weld rejection because of leakage was limited to <1%.

Reference

1. Welding Handbook, Sec. 3, Part B (American Welding Society, 1971).

FIGURE CAPTIONS

<u>Figure 1</u>	Welding Apparatus
<u>Figure 2</u>	Entron Welding Power Supply
<u>Figure 3</u>	Dosimeter Welding Sequence
<u>Figure 4</u>	Welding Apparatus Positioned for Loading
<u>Figure 5</u>	Welding Apparatus Positioned for Weld
<u>Figure 6</u>	Dosimeters are Radiographed to Assure Material
Concentricity
<u>Figure 7</u>	Hydro-forming Die Assembly and Dosimeters at Various
Stages of Completion

WELDING APPARATUS

FIGURE 1

FIGURE 2

DOSIMETER WELDING SEQUENCE

FIGURE 3

FIGURE 5

PHOTO 1831-72A

**DOSIMETERS ARE RADIOGRAPHED TO
ASSURE MATERIAL CONCENTRICITY**

FIGURE 6

FIGURE 7