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Encapsulation of Plutonium
and Other Radioactive Materials
in Welded Containers



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by

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ENCAPSULATION OF PLUTONIUM AND OTHER RADIOACTIVE MATERIALS
IN WELDED CONTAINERS

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ABSTRACT

In connection with the charging and sealing of plutonium alloy into fuel capsules for LAMPRE (Los Alamos Molten Plutonium Reactor Experiment), production equipment and a procedure have been developed that have general application. Radioactive or other noxious materials are loaded into cylindrical containers without contaminating the outside of the containers, an inert atmosphere is provided, and the containers are welded shut. The equipment consists of a welding fixture, atmosphere controls, and a power supply. The procedure depends on careful handling and the convenience of the equipment.

INTRODUCTION

Plutonium is extremely reactive and is subject to rapid oxidation, particularly in moist atmospheres. Further, plutonium is one of the most dangerous poisons because of its radioactivity (alpha-particle emission) and its tendency to deposit in the skeleton where it may produce bone disease. Because of its toxicity, plutonium is processed in air-tight enclosures called glove boxes. To prevent oxidation, the metal is stored in vacuum or in high-purity inert atmospheres.

One procedure for storing plutonium in an inert atmosphere is to place the metal in a container, evacuate the air, backfill with inert gas, and weld an end cap on the container so that it is hermetically sealed. Plutonium canned in this manner can be stored indefinitely. The material is normally sealed in stainless steel, although

for certain special applications it may be sealed in copper, nickel, tungsten, or tantalum as in LAMPRE.

This report describes a welding fixture, associated equipment, and a procedure for encapsulating plutonium in tubes. The encapsulation is performed in a welding fixture in a hood attached to a glove-box line. By careful handling, the outside of the container is kept free from radioactive contamination. Although developed for handling plutonium, the equipment is also used for packaging other materials in inert atmospheres.

EQUIPMENT

A general view of the equipment and work area is shown in Fig. 1. The equipment includes a hood, welding fixture, high-amperage power supply, low-amperage control unit, weld-cycle programmer, and a control panel

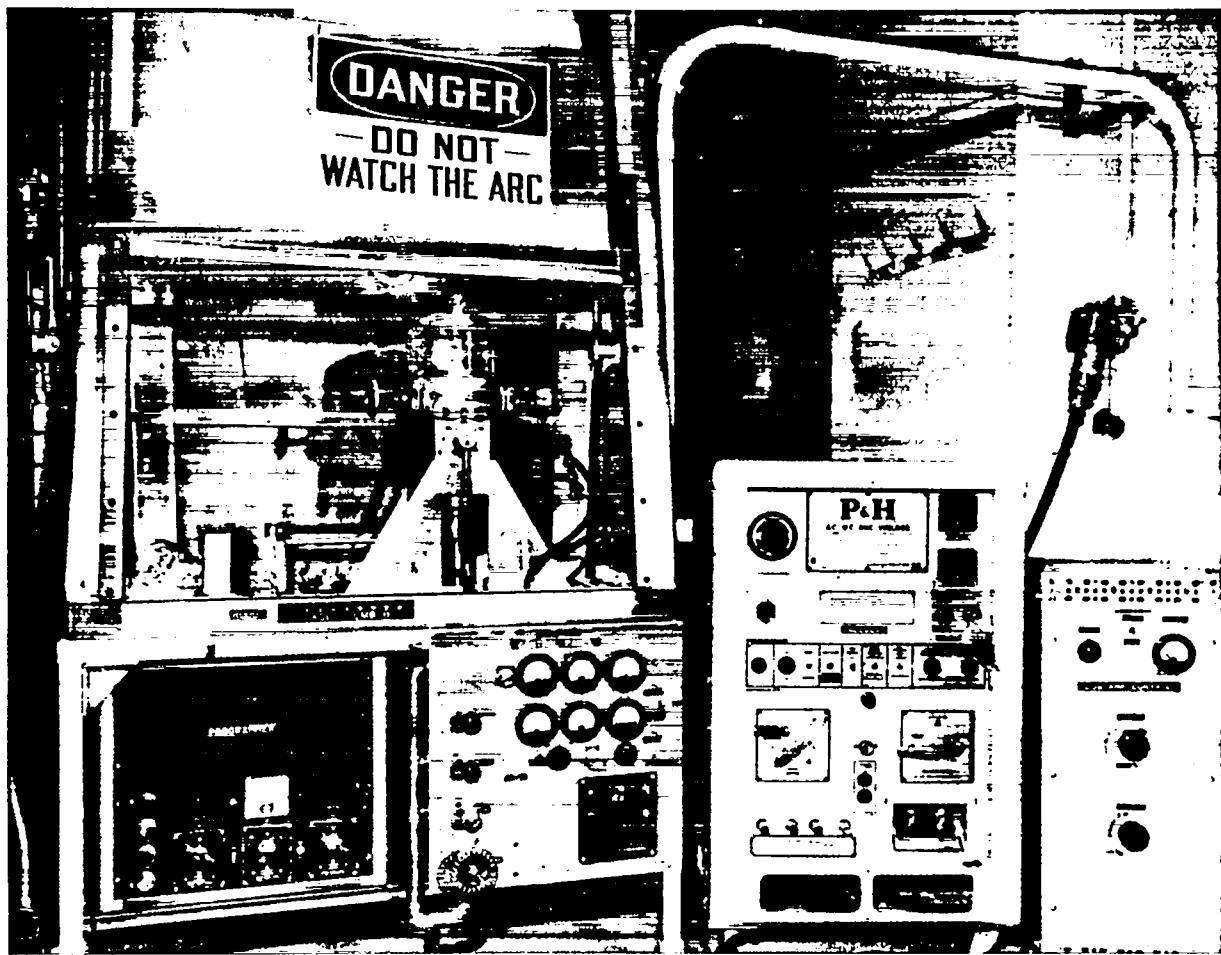


Fig. 1. Welding equipment for encapsulating radioactive materials in metal containers. Top left: hood and welding fixture (glass bonnet attached). Bottom, from left to right: weld-cycle programmer, control panel, arc welder, and low-amperage control unit.

containing atmosphere controls and various electrical controls. Long, small-diameter electrodes are used. Details of the welding fixture and the other components are described below.

High-Amperage Power Supply

The welding power source is a Harnischfeger Corporation (P and H), Model DAR-300 HFGW, 300-A AC-DC arc welder. Other similar machines would be equally satisfactory. The 300-A machine is desirable because some copper and tungsten encapsulations require over 200 A. The output can be fed through a low-amperage control unit or directly to the welding electrode in the fixture.

Low-Amperage Control Unit

Because the high-amperage power supply cannot be controlled satisfactorily at outputs below 15 A, a low-amperage control unit that provides fine control at outputs as low as 3 A is used for the less than 15 A required for thin-wall stainless-steel and nickel containers. Although a low-amperage power supply would provide an alternate system, the infrequent need for low-amperage current led to use of the auxiliary low-amperage control unit as described below.

The P and H power supply, set at 25 to 30 A, is fed through the low-amperage control unit where the current is reduced to the desired level (using one high-capacity resistor as a coarse control and the other as a fine

control) and is supplied to the electrode in the fixture.

Weld-Cycle Programmer

The weld-cycle programmer is shown at the left in Fig. 2. The timer at the lower left of the control box regulates the length of the upslope of the cycle; the timer at the right regulates the downslope. Knobs directly above the timers regulate the rate of change of current from the arc welder during the upslope and downslope. The third timer is used to obtain the proper length of weld cycle.

The variable voltage output of the upslope and down-slope controllers regulates the supply voltage to the saturable reactor control in the P and H power supply, which, in turn, controls the current output of the welder.

Control Panel

The control panel shown at the right in Fig. 2 contains the valves for evacuating the welding chamber and backfilling with either argon or helium. The panel also contains a variety of electrical controls: the main switch, which activates the programmer weld-cycle; emergency shutoff control; welding-current and voltage gauges; vacuum thermocouple gauges; variable speed control for

the welding-fixture-chuck drive unit; and controls for the hot-wire gas-purity tester in the welding chamber.

Welding Fixture

The welding fixture accommodates tubes up to 1 in. in diameter. Figure 3 shows the welding fixture with a metal bonnet having glass view ports. Figure 4 is a schematic of the welding fixture.

Four suitcase clamps lock the bonnet to the fixture base. The bonnet lid is similarly attached. The spring-loaded round knob at the bottom center of the fixture (visible in Fig. 3 through the cutout in the front of the support yoke) positions the weld container vertically. The chuck wrench, a similar knob on the side of the fixture (at the left in Fig. 3), locks the container into the eight-jaw chuck. The bellows unit on the bonnet lid is used for positioning the end cap onto the container after the desired inert atmosphere is obtained.

Figure 5, a photograph of the fixture with the bonnet removed, shows the eight-jaw chuck and the long, fine-wire electrode. After the container end cap has been inserted, the tip of the electrode is remotely positioned, using the two micrometer adjustments on the electrode

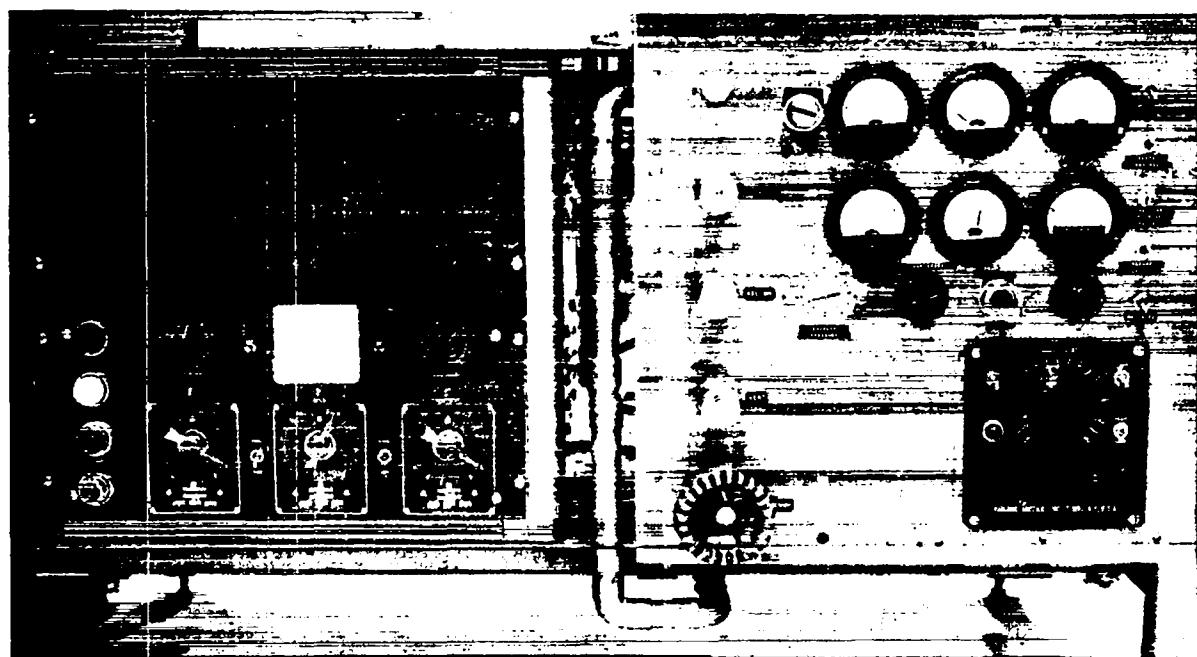


Fig. 2. Left: weld-cycle programmer. Right: control panel for atmosphere controls and a variety of electrical controls.

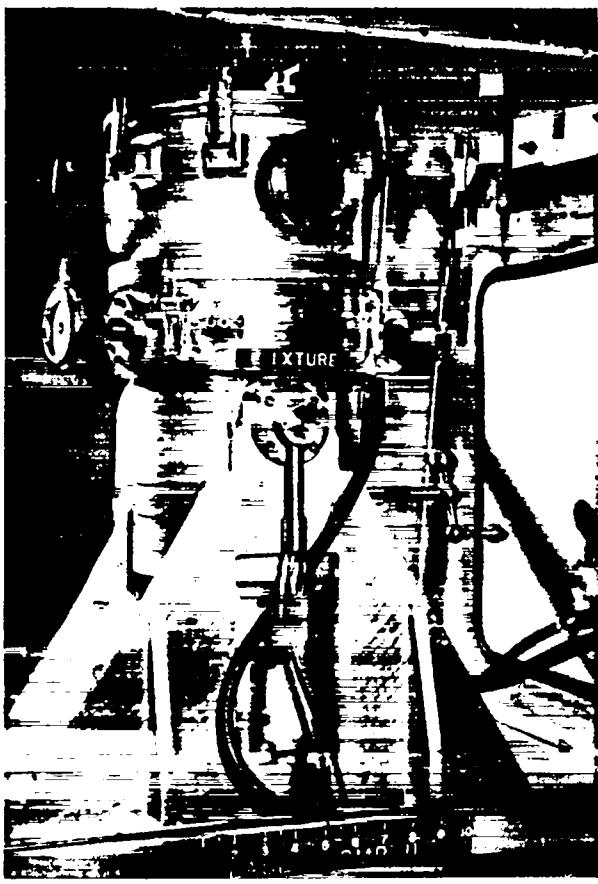


Fig. 3. Assembled welding fixture (metal bonnet with glass view ports).

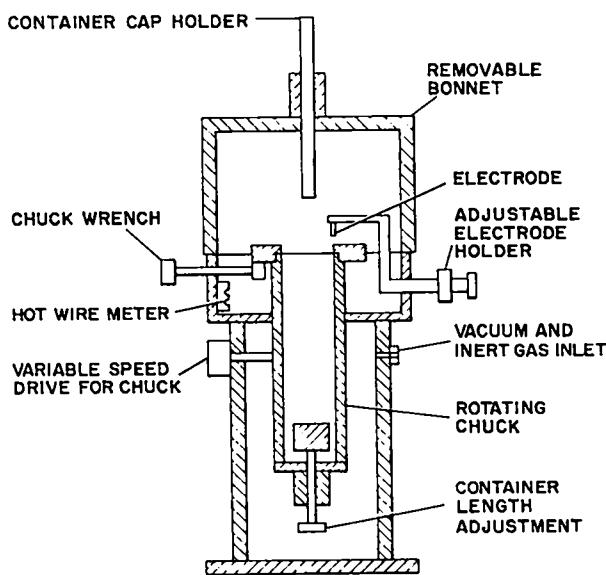


Fig. 4. Welding fixture schematic.

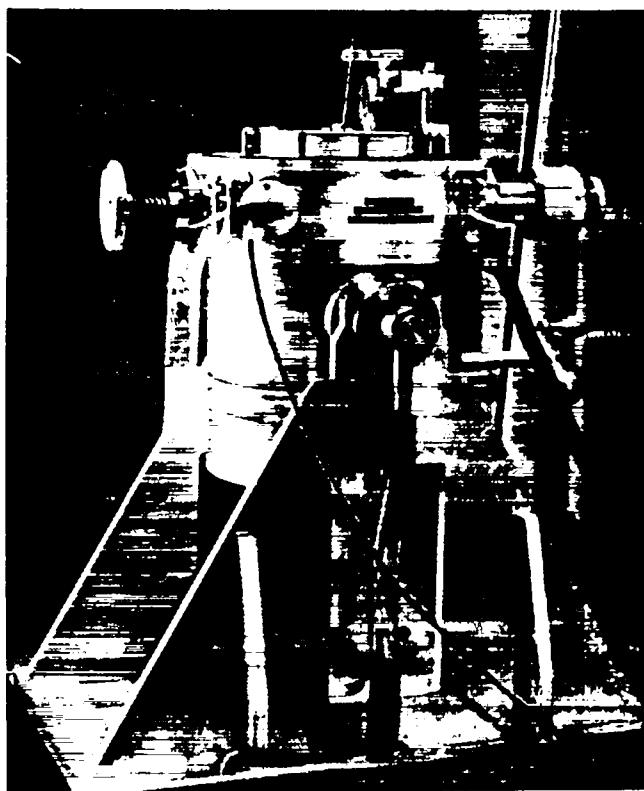


Fig. 5. Welding fixture with bonnet removed. The long, fine-wire electrode, extending to the container lip and the eight-jaw chuck, is visible.

holder (shown at the right in Fig. 5). Vertical and horizontal movements of 0.25 in. are available. The welding current enters the base through an insulator plate (not visible) and reaches the electrode through a flexible copper strap.

The round, white plastic insert adjacent to the bonnet clamp at the left of the figure is a hot-wire gas-purity test meter. A constant current is supplied to a 1.5-in. length of 1-mil tungsten wire wrapped between two posts inside the chamber. Because the life of the filament is directly related to the quality of the atmosphere in the chamber, the filament can be checked prior to the welding for control of the quality of the atmosphere. In addition, the hot filament provides light which is useful for positioning the end cap and electrode.

In Fig. 6, the fixture is tilted for the horizontal welding desirable for certain types of end cap. The fixture, shown with a plastic bonnet, can be tilted up to 90°. The ends of a 1/4-in. -diam-tube welded around the base

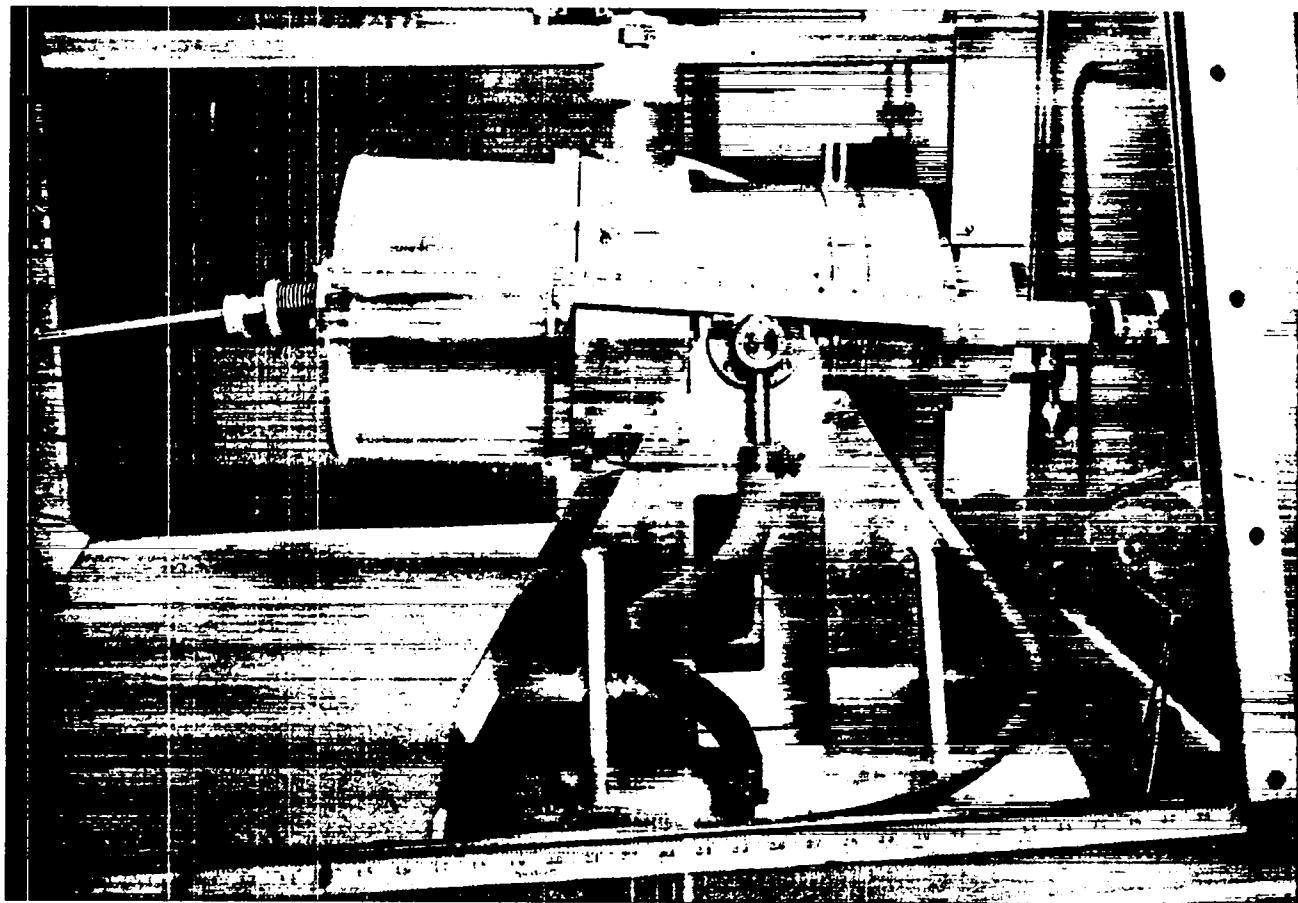


Fig. 6. Welding fixture (with plastic bonnet) tilted for horizontal welding.

of the fixture are visible in the upper right-hand corner of the figure. This line can be used for water cooling, if desired.

Long, Small-Diameter Electrodes

Long, fine-wire, tungsten-2% thoria electrodes are used. The long, small-diameter electrodes have proven very satisfactory. Their use has eliminated the need to grind electrode tips. When a tip becomes corroded, it is broken off and welding is resumed; no further finishing of the tip is required. The long heat-affected zone provides a reproducible high resistance during the weld cycle and has a stabilizing effect on the current. Figure 7 shows a typical arc, as photographed through a plastic bonnet.



Fig. 7. Typical arc, showing long heat-affected zone of the electrode (photographed through a plastic bonnet).

LOADING AND WELDING PROCEDURE

A typical procedure for encapsulation of plutonium follows:

1. Wearing protective clothing and a respirator, an operator holds the container perpendicular to the floor of the hood and transfers the plutonium rod from the glovebox line to the metal container (Fig. 8). A thin-wall (0.0005 in.) funnel positioned in the end of the container facilitates loading and protects the end of the container from plutonium contamination.

2. The loaded container is positioned in the chuck (Fig. 9) so that the open end of the container is about 0.1 in. above the copper chill block in the chuck; the chuck jaws are tightened.

3. The bonnet, containing the end cap held by an "O" ring on the insertion arm, is positioned and clamped to the fixture base.

4. The weld chamber is evacuated to 100 μ and is backfilled with helium three times.

5. The hot-wire meter is turned on, the end cap is positioned, and the electrode is set to the proper gap. The electrode gap is set by inserting the electrode tip

until it touches the capsule lip and by adjusting the horizontal and vertical micrometers to the desired setting.

6. The hot-wire meter is turned off.

7. The chuck drive unit (which rotates the capsule) is turned on.

8. Argon is bled into the chamber through a valve near the electrode holder. Excess gas escapes from the chamber through a pressure regulator that maintains a positive gauge pressure in the chamber of 1 in. of water.

9. The weld-cycle programmer is started.

10. After the capsule is welded, it is allowed to cool before the argon flow is stopped. The bonnet is detached and the welded capsule is removed.

Careful handling during loading and welding can keep the exterior surface of the capsule free from alpha contamination. Typical welds are shown in Fig. 10. Table 1 gives the welding parameters for a variety of containers and end caps.

SPECIAL WELDING FEATURES

Welds can be made with reduced atmospheres in the chamber. Inert gas pressures of 5 in. of mercury absolute are sufficient for welding; current requirements are higher, however.

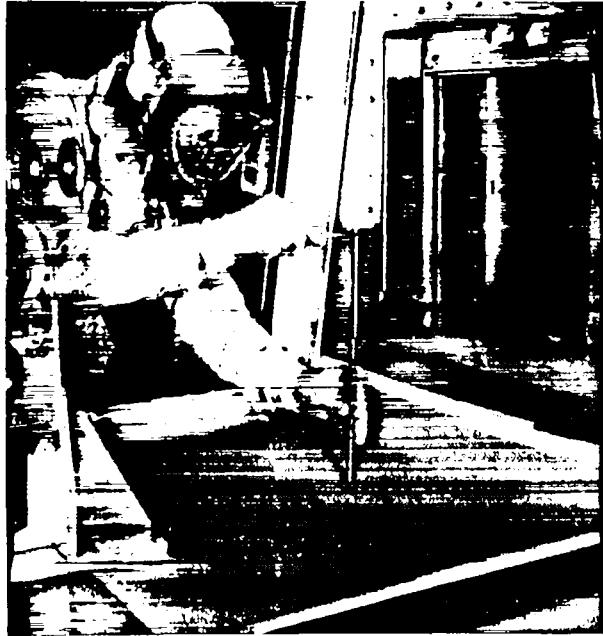


Fig. 8. Insertion of plutonium rod into container.

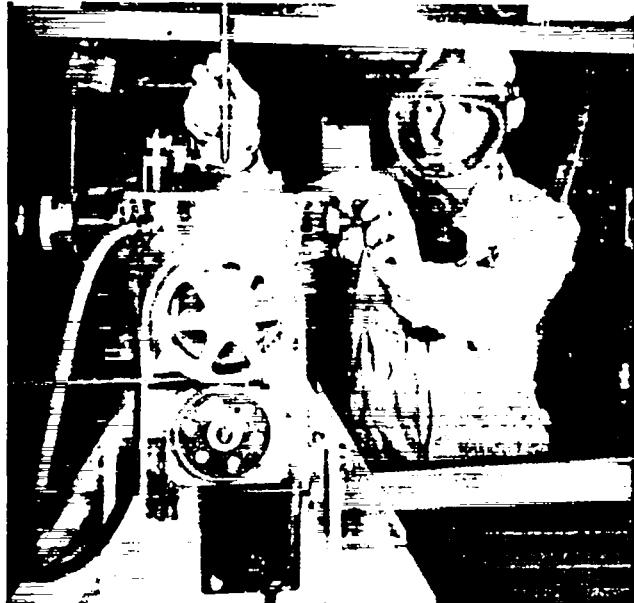


Fig. 9. Insertion of loaded container into welding fixture.

Table 1
Welding Parameters for Various Containers and End Caps

Container			Type End Cap ^c	Weld Program			Container Rotation sec./rev.	Electrode Diameter in. ^b	Electrode Gap in.	Fixture Position From Vertical	Current During Welding Amp
Material	Diameter in.	Wall Thickness in.		Up Slope sec.	Weld sec.	Down Slope sec.					
Ta	0.440	0.030	1 or 2	5	15	5	12	0.060	0.060	0*	100
Ta	0.440	0.030	3, 4 or 5	5	13	5	10	0.060	0.050	0*	40
S. Steel	0.750	0.035	3, 4 or 5	5	20	5	16	0.020	0.050	0*	15
S. Steel	0.875	0.125	6	5	15	5	12	0.060	0.050	45*	80
M. Steel	3.000	0.060	6	5	55	5	48	0.060	0.060	0*	65
Cu	0.875	0.050	3	5	10	2	8	0.093	0.090	0*	120
Ni	1.500	0.005	6	5	50	5	48	0.010	0.025	80*	8
Au	0.750	0.030	3 or 4	5	15	5	12	0.040	0.020	0*	36
W	0.750	0.060	3	5	23	5	18	0.125	0.125	0*	165
Wa	0.750	0.060	3	5	23	5	18	0.125	0.090	0*	180

a Weld chamber at 6 in. absolute argon pressure

b Electrodes 2% thoriated tungsten

c Type end caps

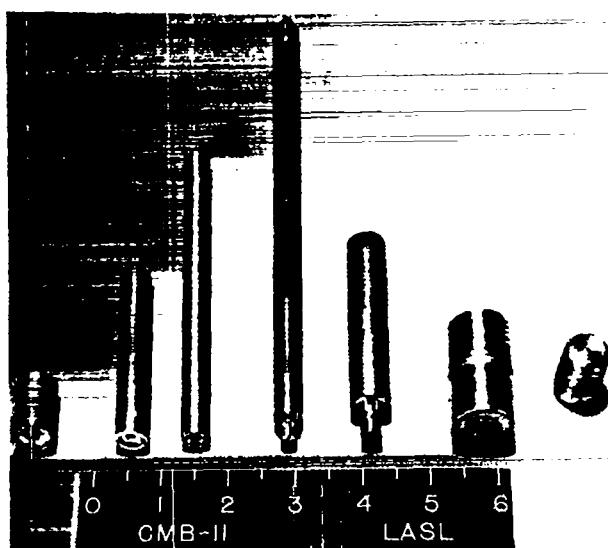
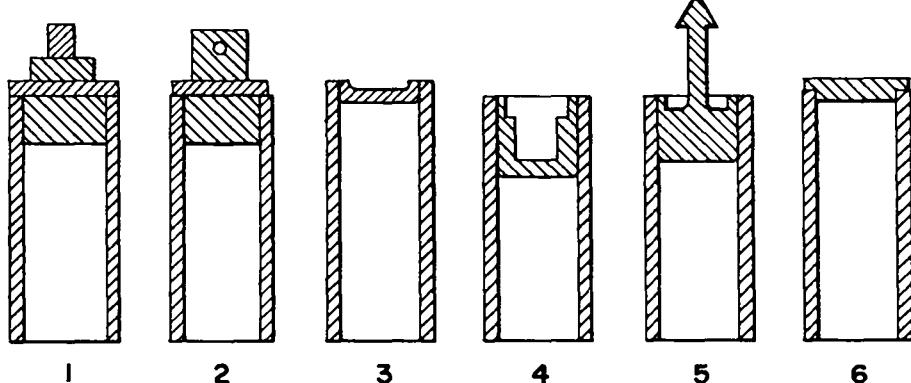


Fig. 10. Typical welds.

Containers measuring up to 3 in. in diameter can be welded in a larger, similar fixture, which is mounted on a portable stand. Plug-in gas and electric connections permit use of the welding power supply and control unit used for the smaller fixture.

Containers measuring up to 30 in. in length can be handled by inserting an extension sleeve between the vertical adjustment housing and the base of the weld chamber.

SUMMARY

The welding equipment and procedure described provide a method for encapsulation of radioactive materials while keeping the outside surface of the container free from radioactive contamination. The welding fixture permits high-quality inert atmospheres to be provided in encapsulation containers outside of the confines of large, vacuum-inertable glove boxes. The versatility of the equipment--permitting a variety of container sizes, and

programmed welding current from < 10 to > 200 A--makes it a useful tool in the laboratory.

ACKNOWLEDGMENTS

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