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ULTRASONIC AND RESISTANCE WELDING OF
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W. I. Steinkamp

August 8, 1961

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ULTRASONIC AND RESISTANCE WELDING OF
EE SUPPORTS TO EE FUEL ELEMENT CLADDING

W. I. Steinkamp

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Tube-tube type fuel elements require support devices to maintain concentricity both between the element components and between element and process tube. A variety of support devices have been conceived. All require welding of a tab or other attachment device to the Zircaloy clad. Ultrasonic and resistance welding were evaluated for this application.

Investigation showed ultrasonic welding to be not acceptable in its present state. Resistance welding proved satisfactory.

This paper will briefly cover the work done in evaluating the two methods of attachment.

The initial criteria for support attachment welds included the following: Neither the grain structure of the uranium nor the Zircaloy-uranium bond must be affected by the weld. The welds should have a certain minimum

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shear strength and should be consistently near that strength. The welds should be reproducible and no clad damage either from jiggling or the weld itself can be tolerated.

The support welding involved three separate welds. A support had to be attached to the outer tube. This clad was 0.030" thick. A support had to be attached to the inner tube. This clad was 0.040" thick. A locking device had to be attached to the inside surface of the outer tube. The different supports and locking devices ranged from 0.030" to 0.040" thick. Slide 1 shows a cut-away section of an element showing the relative position of these welds.

The ultrasonic welding was done partially offsite and partially at Hanford. The same 4,000 watt welder was used and there was no appreciable difference between results. The primary difficulty arose over a crack in the clad which appeared beneath 85 per cent of the welds. Slide 2 shows a typical crack. This weld is from the group made at Hanford. These appear on sections taken in the plane of welder tip motion only. A variety of surface preparations were tried, but the cracking could not be eliminated. Slide 3 shows transverse and longitudinal sections of one of the offsite welds.

Although welding was done on a 4,000 watt unit, in general weld conditions were in the range of 1600 - 2700 watts, 200 - 250 pounds clamp pressure, and 0.2 to 0.7 seconds weld time. These conditions achieved welds with strengths of approximately 1300 pounds. This was more than adequate strength, but the cracks which penetrated as much as one-third the depth

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of the clad could not be tolerated so the method was changed in favor of resistance welding.

The resistance welding was done on a 100 KVA three-phase machine with provision for operating it single phase and an increased voltage feature which made it possible to double the secondary voltage to 8.8 volts. A low inertia electrode holder was available. The various combinations were investigated with these results. Operating the machine three phase or single phase with a 4.4 volt secondary and a standard electrode holder, it was possible to make welds with over one thousand pounds shear strength which did not melt the uranium core but all such welds did produce a heat affected zone of enlarged grains in the uranium. When the machine was operated single phase with 8.8 volt secondary it was possible to make welds which had the same strength and did not have this heat affected zone in the uranium. If a standard electrode holder was used the pressure required was 350 pounds. The low inertia electrode holder allowed the pressure to be reduced to 100 pounds and made equal welds at a slightly lower weld current setting.

A series of welds were made with the machine operating three phase and using a standard holder to determine how critical the settings were. Slide 3 shows some welds of this series. The one made at 27 per cent phase shift makes just enough weld to attach the support while the one made at 57 per cent actually shows uranium in the weld nugget. A fuel element with a support attachment weld almost identical to the 57 per cent weld shown underwent a 1400 MRD/T irradiation with no ill effects.

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A continuity run was made on the 0.040" support to 0.040" clad welding. This was a series of 1,000 welds made in three sections with the machine being used for other jobs between sections and using no setup other than returning the machine settings to their original values. Thirty-one welds were picked at random for metallographic examination. The rest were shear tested. Eighty-eight per cent showed shear strengths above one thousand pounds.

Slide 4 shows a typical section of one of these welds. Weld conditions were 100 pounds, 3/4 per cent phase shift, one cycle, one impulse, single phase.

A much shorter run was made on the 0.030" support to 0.020" clad. A typical weld is shown in Figure 5. This was made at 350 pounds with a standard electrode holder. Welds made with the low inertia holder show slightly less depth of heat affected zone in the Zircaloy.

This demonstrated that the supports could be adequately attached by resistance welding without any damage to clad or core. As this is written, some mechanical problems of properly locating and sizing the support devices remain, but an early solution is in sight.

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