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**UNDERWATER REFURBISHING
OF FUEL ELEMENTS**

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and
R. E. SHARP

DECEMBER, 1965

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UNDERWATER REFURBISHING OF FUEL ELEMENTS

By

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Ceramics Laboratory Section
Reactor and Materials Technology Department

December, 1965

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ABSTRACTUNDERWATER REFURBISHING
OF FUEL ELEMENTS

Tools and procedures were developed to make underwater repairs to wire wraps and metal bands for fuel elements. Substantial cost savings have been realized, and new applications have been discovered relative to underwater removal and replacement of fuel rods in the fuel cluster and assembly and disassembly of segmented fuel rods.

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UNDERWATER REFURBISHING OF FUEL ELEMENTS

INTRODUCTION

This report discusses the tools and procedures which were developed to perform underwater operations relative to the refurbishing of fuel elements, assembly of segmented fuel rods, and replacement of fuel rods. With the use of extended reach hand tools, underwater repairs were made to broken wire wraps and broken bands on Plutonium Recycle Test Reactor (PRTR) fuel rod assemblies in the reactor storage basin.

Fuel elements for the PRTR are assembled in clusters of 19 fuel rods held together by metal bands. The rods are spaced in the cluster by unbanded wire wraps which are fastened only at the rod ends. Occasionally a wire wrap will break near its termination at the end of a rod, or a band will be torn loose on the fuel element. This type of damage prevents the safe return of a fuel element to the reactor for further irradiation.

During the course of this underwater work, fuel rods were removed and replaced in the fuel cluster, and a segmented fuel rod was assembled and disassembled.

SUMMARY

Substantial cost savings have been realized by the underwater repair of damaged PRTR fuel rod assemblies. Development of extended reach hand tools has made it possible to accomplish underwater refurbishing of fuel elements in the reactor storage basin.

UNDERWATER REPAIR OPERATIONS

Facilities

The PRTR storage basin facilities were used in this project. Figure 1 shows a view of the work area. The basin is equipped with a fuel element handling tray that can move a fuel element from a vertical to a horizontal position. In the horizontal position the fuel element rests on rollers and can be rotated by turning a chuck which supports the lower end bracket of the fuel element. To optimize the working depth and to minimize

radiation exposure to the worker, the fuel element and tray can be raised or lowered in the basin. Lighting was provided by underwater lamps, either mounted or hand held. The use of a 20 to 60X spotting telescope enhanced visual examination.

Repair of Fuel Rod Wire Wrap

The repair of one broken wire wrap takes from 2 to 3 hr. A typical repair job is shown in Figure 2. Extended reach underwater hand tools (Figures 3 and 4) include an air-operated drill for drilling a hole in the end hanger, a special tool for holding the wire connector which permits the broken wire to be inserted into the connector, crimping pliers for crimping the ends of the wire, punches, cutting pliers, and a right angle wrench.

Wire wrap repairs are performed with the fuel element lying horizontally on the storage basin fuel handling tray 2 to 3 m underwater. A 6.35 mm diam hole is drilled through the end hanger fin closest to the broken wire on the fuel element, thus providing a means for placing a screw to clamp the wire to the fin. The loose end of the broken wire is cut back to provide a straight length of wire. A connector with a new piece of wire 10 m long is placed in a special holding tool (Figure 4). When the holding tool is closed around the connector, the funnel-like entrance guides the broken wire end through the connector. Pushed through the connector, the broken wire end is crimped with special pliers made from a pair of "vise grip" pliers, and the special holding tool is removed. Extended reach diagonal pliers cut off the excess wire protruding beyond the connector. The long new piece of wire is run through the end hanger, and the free end of the wire is brought above the surface of the water. Held by a pair of extended reach vise grip pliers, a screw is slid down the wire and placed in the 6.35 mm hole in the end hanger fin. While the screw is being held in the hole, a right angle wrench (Figure 5) is used to fit a nut on the screw. Once the nut is started, the loose end of the wire is pulled up tight, and the nut is then tightened to secure the wire. The excess wire extending beyond the screw is cut off, completing the repair. The new wire and connector are placed so that they lie between two rods.

Banding of Fuel Rod Assemblies

Made of stainless steel, the underwater banding tool is 3.5 m long and can be operated by one man. It takes about 5 min to place one band. The band consists of two loops of 0.43 mm thick by 4.83 mm wide Zircaloy-2. In this procedure, the band is pulled up tight through a rack and pinion gear by the operator. After the band is tightened on the fuel element, the banding sleeve is crimped, and the extra length of banding is bent over a sharp edge on the tool and broken off. Figure 6 shows the banding tool installing a band, and Figure 7 shows the band and crimped sleeve securely holding the fuel element.

Assembly of Fuel Rod Segments

During the last several years, the Hanford Laboratories (now Pacific Northwest Laboratory) has had under development a fuel reprocessing method called the "Salt Cycle Process." Essentially, this process provides relatively simple nuclear fuel reprocessing and remote fuel element refabrication methods that could be closely integrated with a specific reactor, thus lessening the need for a large central chemical reprocessing plant. In the salt cycle process, set up on a small scale in a hot cell, the fuel, composed of PuO_2 - UO_2 and some of the fission products, was electrodeposited from a molten salt solution in which the irradiated fuel was dissolved. A majority of fission products (poisons) are not deposited out of solution. Because of the radiation from the remaining fission products on the deposited fuel, new fuel elements must be fabricated, assembled, and banded in a shielded facility.

Thirty-three fuel rod segments (from salt cycle fuel), containing 2 wt% PuO_2 , were recently fabricated remotely in a cell. Restricted to about 20 in. in length because of space limitations in the cell, these rods were vibrationally compacted, welded remotely, and transported to the PRTR storage basin. Under the water in the basin, 18 rod segments were joined to form six 60-in.-long rods. Figure 8 shows three rod segments before assembly. In this experiment, three complete rods (total of nine

segments) were placed in an element, and then the element was banded as described earlier. All the work was performed under 2 to 3 m of water, with no difficulties. The bottom segment was placed in the fixture shown in Figure 9. With a slot fitting the hex on the segment end caps, this fixture keeps the rod from turning when the next segment is screwed into place. When the first segment is placed in the fixture, a Zircaloy-2 sleeve is attached to the cap and the next segment is gripped (on the end cap hex) in a special wrench and screwed into place (Figure 10). The wrench is then released and removed, and two joined segments are lifted out of the fixture and dropped down. The third segment is screwed into position in the same manner, completing the assembly. The completed fuel rod is then laid into an open position in a fuel bundle and held in place by a screw inserted through the top end hanger and screwed into the end cap on the top fuel rod segment. These steps are depicted in Figures 11 and 12.

Replacement of Fuel Rods

Three experimental fuel elements were irradiated in the PRTR. After some irradiation, three fuel rods were removed (on separate occasions, two in one instance and one in the other) and replaced with new rods. Using tools shown in Figure 4, these rods were replaced under about 2 to 3 m of water in the reactor storage basin.

CONCLUSIONS

The underwater fuel element refurbishing program has resulted in cost savings of \$3,000 to \$5,000 for each damaged PRTR fuel element that has been salvaged. Developed to effect the underwater repairs of damaged fuel rod assemblies, the relatively simple extended reach hand tools used in this work might be effectively employed in a proposed fuel re-use program,⁽¹⁾ wherein blanket fuel from a fast reactor is assembled into fuel elements for thermal reactor use. The assembly and disassembly of segmented rods could be a simple way of doing this job.

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FIGURE 1
PRTR Storage Basin Work Area

FIGURE 2
Fuel Rod Assembly
with Repaired Wire Wraps

FIGURE 3
Underwater Air-Operated Drill Motor and Drill

FIGURE 4
Wire Connector Holding Tool

FIGURE 5
Bonding Tool, Rod Wrench,
Rod Bonding Tool, and Right Angle Wrench,

FIGURE 6

Installation of Band on a Fuel Rod Assembly

FIGURE 7

Fuel Rod Assembly with Band in Place

FIGURE 8
Fuel Rod Segments

FIGURE 9
Assembly Fixture and Rod Segments

FIGURE 10
Assembly of Rod Segments

FIGURE 11
Placing Segmented Fuel Rod
in Fuel Rod Cluster

FIGURE 12
Inserting Screw in End Hanger and Cap

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