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SRE FUEL ELEMENT DAMAGE

FINAL REPORT

OF
THE ATOMICS INTERNATIONAL AD HOC COMMITTEE

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I. INTRODUCTION AND CONCLUSIONS

During the course of power run 14 on the Sodium Reactor Experiment (SRE) at low power, temperature differences among various fuel channels were found to be undesirably high. Normal operating practices did not succeed in reducing this temperature difference to acceptable values, and on July 26, 1959, the run was terminated. A series of fuel element inspections was begun to ascertain the cause of these circumstances, and 13 of the 43 fuel elements were discovered to have suffered substantial damage.

On July 29, 1959, an Ad Hoc Committee was appointed to:

a) Assist in analysis of the existing situation in the reactor and determination of its origin;

b) Review and advise on steps taken to remedy the situation and bring the reactor back into operation;

c) Recommend any necessary changes in operating procedures or the reactor system to prevent occurrence of a similar situation.

On November 15, 1959, the Committee issued an interim report, "SRE Fuel Element Damage," NAA-SR-4488,[1] which reported on the origin, the nature and consequences of the damage to the SRE fuel based on activities, data gathered, and evaluations performed to October 19, 1959. The Ad Hoc Committee has now completed its investigations. This final Committee report revises and supplements the earlier interim report.

Since the publication of the interim report, sodium was drained from the reactor system and the top of the reactor remotely inspected and cleaned. Sixteen moderator cans were removed and replaced. Sodium coolant was returned to the reactor system for continuous circulation with cold trapping for impurity removal. Information on recovery equipment and techniques used will be published.[2]

As a result of the evaluation of the data accumulated during the first core operation of the SRE, a number of system modifications have been made.[3] These changes include elimination of tetralin as a service coolant, modification of the fuel element design, installation of a continuous cover gas monitor, and installation of a number of instruments designed to provide more detailed data on reactor

III. DATA AND EVALUATION

A. FUEL DAMAGE INFORMATION

Since the Interim Report was written, more information has been obtained on the mode of failure of the fuel elements. A tentative conclusion of the Interim Report was that the elements had failed through diffusion of uranium into the cladding to form low melting alloys. Such alloys had been identified through chemical analyses of pieces of cladding and wire wrap taken from the area of failure. It was stated that the high temperatures required for the diffusion process had been produced by local plugging of the coolant channels by tetralin decomposition products, and photographs of such plugs were shown. Much of the new information was obtained from the examination of a complete element in the Component Development Hot Cell (CDHC). The additional data demonstrate that temperature cycling was a major contributor to the failures.

1. Examination of Element From Channel R-24

When the parent report was written, two complete fuel elements remained stuck in their coolant channels. These were the elements in channels R-24 and R-76. They were removed from the core along with the associated moderator assemblies.

The assembly containing channel R-24 was moved to the CDHC where it was opened in an inert atmosphere. The moderator assembly was sectioned axially and the outer can and graphite removed. The zirconium process tube was then cut axially and the tube opened, exposing the fuel element.

The results are shown in Figure III-1. Several features should be noted: (a) the solid plug of material about 1-ft above the bottom of the fuel rods, (b) the Fe-U alloy melt-through area about one-third of the way up the element and extending for several inches, (c) the region above the melt-through where the cladding had been distended until it burst, and (d) the black spongy plug in the channel below the element.

The solid plug was determined metallographically to consist of Fe-U alloy of near-eutectic composition. Its source was the melt-through area above, from which Fe-U alloy, formed near the surface of the slugs, penetrated and destroyed the cladding.

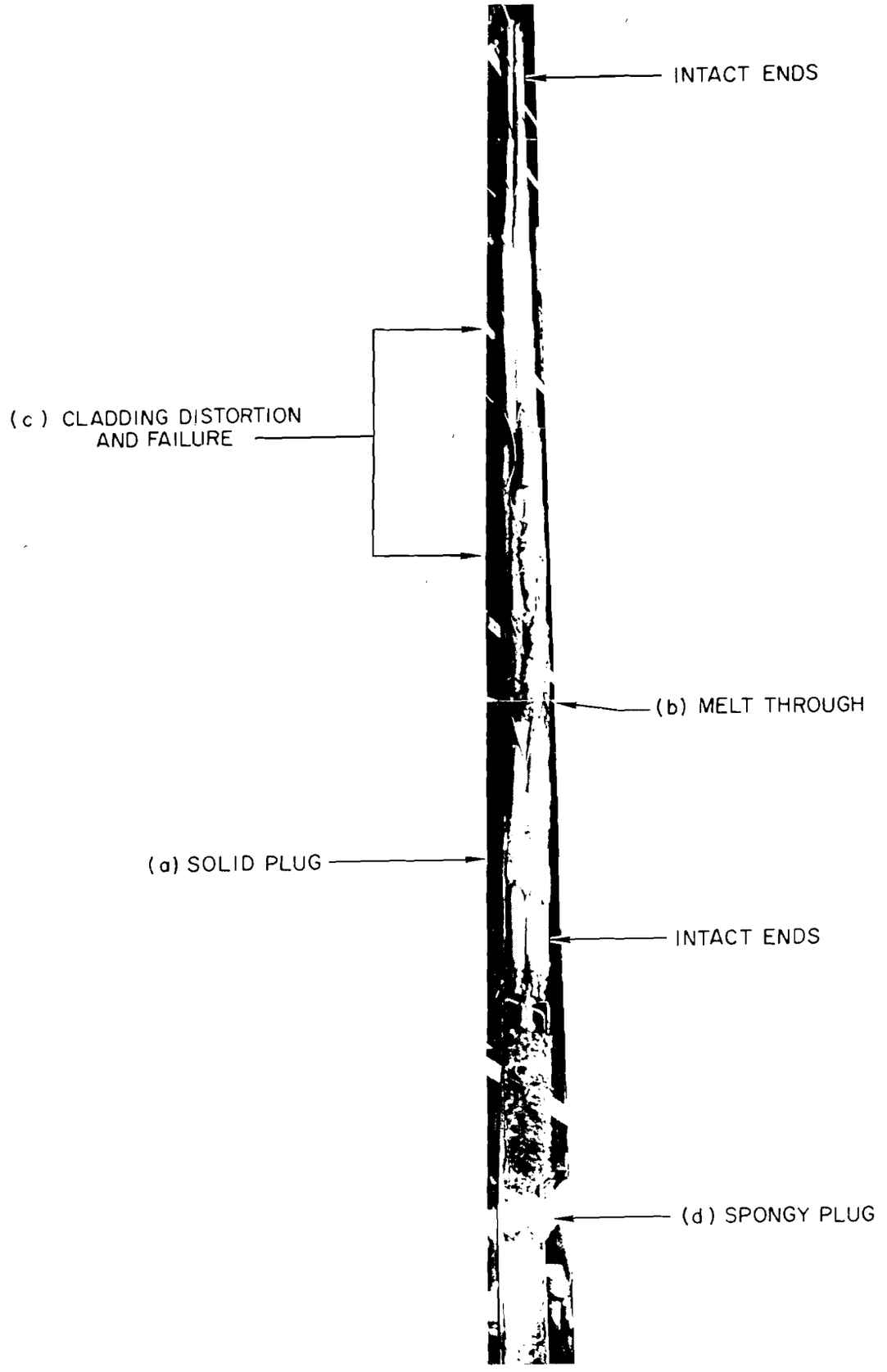

Figure III-1. Fuel Element From Channel R-24