EXPERIMENTAL BREEDER REACTOR NUMBER I, EBR-I CRITICALITY ACCIDENT

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INTRODUCTION

The Experimental Breeder Reactor, EBR-I was the first reactor built at the Idado National Laboratory, INL. It began operation in 1951 and produced the first usable electricity from nuclear heat on December 20, 1951. It achieved full-power operation the next day.

In 1953, the reactor confirmed that a nuclear reactor designed to operate in the fast neutron range is capable of breeding more fuel than its operation consumes.

The reactor, which used enriched uranium as fuel, was unmoderated. It used a sodium-potassium alloy eutectic (NaK) that was liquid at room temperature as coolant. NaK tended to burn when it came into contact with air. The pipes containing the NaK and the pumps moving it would have to work perfectly for a long time. In case the pipes did fail, the atmosphere into which the NaK leaked should not contain air.

The EBR initially used traditional pumps but they were later replaced by electromagnetic pump as well. These had no moving parts, were completely sealed, and were made entirely of metal.

A blanket of U^{238} around the core provided the "fertile" material in which breeding took place. The liquid-metal coolant permitted the neutron energies to be kept high, thus promoting fissionable-material breeding. The coolant also enabled high-temperature and low-pressure operation, both conducive to efficient power production.

President Lyndon B. Johnson dedicated EBR-I as a National Historic Landmark on August 26, 1966 and it was opened to the public for visits and tours.

Figure 1. Exterior of Experimental Breeder Reactor, EBR-1 plant.

ACCIDENT AT EBR-I

To facilitate the design of EBR-II and the Fermi fast reactors, Argonne National Laboratory turned EBR-I to the task of exploring excursions and the reactor's inherent shut-down potential.

It appeared that under certain conditions, the reactivity in the core increased when the temperatures went up. This is undesirable since a negative temperature of the reactivity is a desirable safety feature.

Attempts were made to increase the EBR-I fuel to a temperature of 500 degrees C. to see if it would lose reactivity. To get the fuel that hot, the drastic step of shutting off the flow of coolant had to be taken.

The safety systems that would automatically scram the reactor before it reached the test temperature were also purposely disconnected. It was known that this could cause a meltdown if a scram was not timed perfectly.

On November 29, 1955, the EBR-I reactor was ready for the test. The plan was to scram the reactor when the power level reached 1,500 kilowatts or when the doubling of the fission rate occurred at a one-second interval. When this moment arrived, an assistant misunderstood the operator's instruction and scrammed the reactor with a slow moving control rod, not the indicated faster one. The operator quickly reached over and pushed the proper button, but the lapse had cost two seconds.

Fifteen minutes later, radioactivity within the control room set off the alarms and everyone evacuated the building. Half of the football-sized core had melted.

The event produced no sound, no steam, no smoke, and no explosion. The scientists absorbed there were lessons to learn and saw an opportunity of perhaps making lemonade out of a lemon, to learn how to handle a damaged core safely and efficiently.

AFTERMATH OF ACCIDENT

The Atomic Energy Commision, AEC Headquarters decided not to inform the public. The news leaked out in April 1956, covered by the nuclear and national presses.

The editor of Nucleonics warned the AEC that nuclear accidents were public business. He said: "Apart from the bad effect that secrecy would have on attitudes toward nuclear safety, such withholding of news is wrong in principle. It is beyond the authority of AEC to withhold information not affecting the national security. And because AEC operates in so much secrecy, public confidence in it will surely be undermined."

Analysis found that in the extraordinary heat, the fuel elements had bowed and expanded, bringing too many uranium atoms too close to one another. The heat had been greater on one side of the elements than the other, and since the fuel was clamped at both ends, it bent toward the higher heat, a simple mechanical event.

In the future, this could be easily prevented by allowing expansion of the ends of the fuel elements.

EBR-I received a new core in 1957 employing zirconium spacers and other features to hold the fuel rigid. EBR-I continued to serve for experiments.

In 1962 ANL installed what would be EBR-I's last core, this one with plutonium fuel. Experiments continued until ANL shut down the reactor in 1964, ready to move on with EBR-II, the next evolutionary step in the march toward commercial-sized fast breeders.

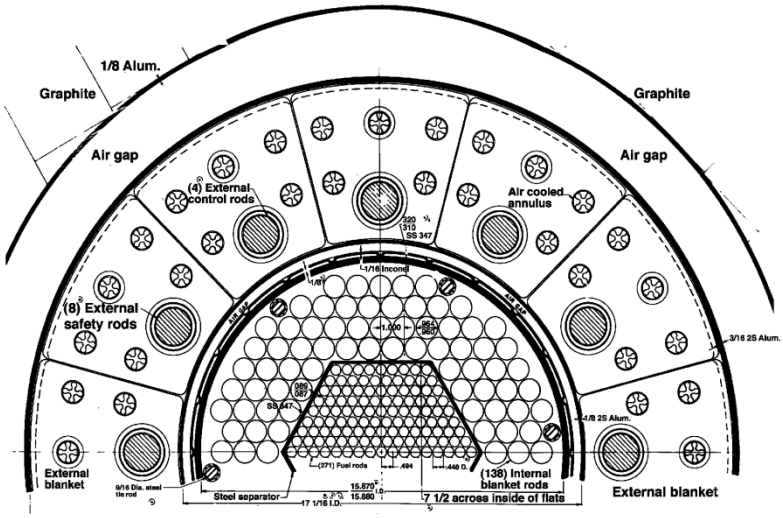

Figure 2: Experimental Breeder Reactor 1, EBR-1 core configuration.

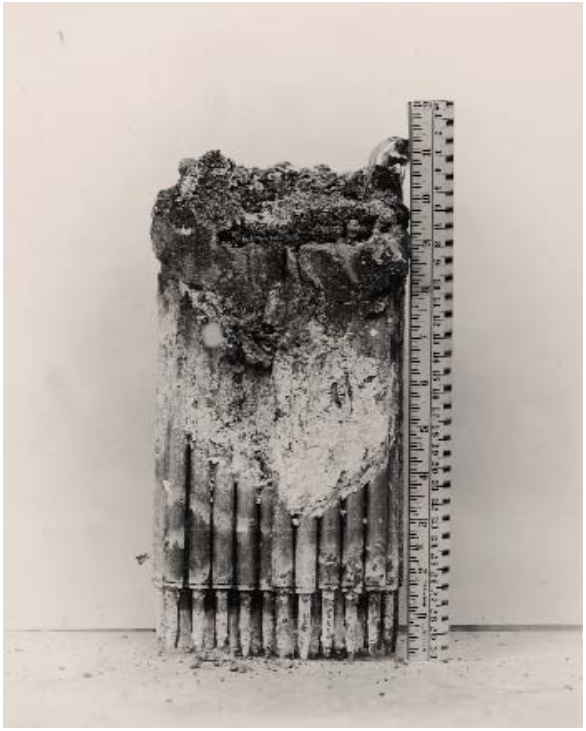

Figure 3. Damaged core of EBR-1 reactor from 1955 core meltdown.

REFERENCE

1. George Voelz, “The SL-1 Reactor,” Chapter 15, in: Suzan M. Stacy, ed. “Proving the Principle - A History of the Idaho National Engineering and Environmental Laboratory, 1949-1999, DOE/ID-10799, 2000.