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Predicted and Measured Response of the EBR-II Plant to Large Steam Pressure Changes*

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The Experimental Breeder Reactor II (EBR-II) is a liquid metal reactor (LMR) whose sodium-bonded metallic fuel core has substantial negative reactivity feedback. It has been demonstrated that this feedback enables a loss-of-flow without scram (LOFWS) to shut the reactor down without operator action. This inherent effect also causes a reactor shutdown following a loss-of-heat-sink without scram (LOHSWS). On April 3, 1986, an LOFWS and an LOHSWS were each performed from full power.[1,2] In the latter test the secondary sodium flow was reduced to less than 1% in about three minutes. This caused the reactor inlet temperature to increase only about 45°C and essentially stopped the fission process and shut the reactor down.

These tests demonstrated that an LMR plant can be designed in which natural phenomena, rather than electromechanical systems (such as those which move control rods), are effective in protecting the reactor against the potentially adverse consequences of loss-of-primary-flow and loss-of-heat-sink accidents. Moreover, the same phenomena which shut the reactor down during these two tests could be exploited to allow primary flow or inlet temperature, rather than control rods, to be used to maneuver plant output within a considerable power range. This capability would enable an LMR to be designed in which far less reactivity is invested in the control rods than is currently the practice. The ultimate goal is to design an "inherently safe" LMR in which reactor safety does not depend upon control rods and also where severe rod withdrawal accidents do not need to be considered.

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Another important mode of potential reactivity addition is a large pressure drop in the steam system. A blowdown of the steam system causes the temperature of the saturated liquid in the system to drop with the pressure. This effect cools down the cold leg of the secondary sodium system, which in turn reduces the reactor inlet temperature after being attenuated by the IHX. Negative reactivity feedback then causes the reactor power and outlet temperature to rise, possibly to an unsafe condition. If the steam system ultimately runs out of water, the transient will begin to recede and behave as a delayed loss-of-heat-sink transient; i.e., the reactor inlet temperature rising and the reactor tending to shut down. Hence, as for changes in primary and secondary flow, large reductions in steam pressure can be a safety issue. On the other hand, pressure changes can be exploited as a means of regulating reactor power and thus factored into the design of an inherently safe LMR.

In May 1985 three pressure change tests were performed on the EBR-II plant. In the first the pressure in the steam system was ramped down 690 kPa (100 psi), held until the plant reached a new steady state condition, and then returned to its initial value. The second and third test were essentially the same except that the pressure changes were two and four times greater, respectively. In the paper we will discuss NATDEMO[3] simulation code predictions of the most severe tests and use measured data to verify the results. The paper will also include a detailed description of the tests, the practical considerations addressed in their design, and the operation of the controller used for regulating steam pressure.

References

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