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## Plant Inherent Control Testing in EBR-II\*

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A testing program is being conducted in EBR-II to demonstrate passive, inherent reactor protection and control. The results thus far strongly support the feasibility of inherently safe passively controlled liquid metal reactors (LMRs) and suggest the possibility of much simpler reactor plant designs. The shutdown heat removal tests (SHRT)<sup>1,2</sup> in EBR-II have demonstrated that a metal fueled LMR can be inherently and safely shut down for either loss of flow without scram<sup>3</sup> (LOFWS) or loss of heat sink without scram<sup>4</sup> (LOHSWS) accident. Data obtained from tests involving primary flow perturbation<sup>5</sup>, reactor inlet temperature perturbation<sup>5</sup>, and turbine pressure reduction<sup>6</sup> of the SHRT program have indicated that the reactor power can be passively controlled over a large range by the primary flow, the secondary flow and the turbine/generator load. These results suggest the possibility of eliminating control rods for normal reactor power control and for fuel burnup compensation. If the reactor power can be passively controlled in the power range without using control rod, then the transient overpower without scram (TOPWS) accidents due to control rod runout can either be eliminated or greatly reduced in severity. The reactor safety associated with the above events can thus be based on inherent safe characteristics of the plant rather than the complicated reactor shutdown system (RSS). As a result, the number of scram functions in the RSS of an LMR can be significantly reduced, and the RSS can become much simpler and less costly.

A Plant Inherent Control Testing (PICT) program is currently being developed in EBR-II to experimentally investigate inherent control concepts for metal fueled LMRs. In all of the tests, the turbine and the generator will be on line and the control rod drive mechanism will be disabled. The reactor

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power and the plant thermodynamic state will be controlled between 40 and 100% power with the primary coolant pumps, the secondary coolant pumps, and the turbine admission valve. The first series of tests will investigate steady-states that may exist for different load following approaches.

In one of the PICT tests described in the paper the power and flow are both initialized at the low end of the power range (~ 40% power, power/flow (P/F) = 1). The test is initiated by slowly increasing the primary flow to 60, 80 and 100% of rated flow in three stages while decreasing reactor inlet temperature to hold P/F constant. At each stage, a steady state will be reached before proceeding to the next stage. The turbine steam pressure will be held constant throughout the test by automatic pressure control via its initial pressure regulator. Due to reactivity feedback in EBR-II, the power will increase with increasing primary flow and decreasing reactor inlet temperature. No external reactivity will be added with control rods. Five other tests are planned in this first series to investigate other combination control variables.

The thermal-hydraulic-neutronic system analysis code, NATDEMO<sup>7</sup> was used for the pretest predictions of the EBR-II plant response. NATDEMO is a generalized code and is currently used for modeling the EBR-II plant. One of the important features of the neutronic section of the code is its validated, detailed model of reactivity feedbacks. This is essential for the predicted plant response for the PICT tests. Figure 1 illustrates the load-following characteristics of primary flow, secondary flow, and reactor temperatures for the test mentioned above.

This first series of tests will be expected to verify the analytical predictions that the plant power can be safely controlled without moving control rods. Data obtained will be used to design an integrated plant control system and to define dynamic tests. The tests will demonstrate plant response to disturbances and abnormal events. These data are expected to contribute to the design of automated control systems of the innovative metal fueled LMRs.

In this paper, the first series of the PICT program will be described in detail. Extensive data collected from SHRT tests will be used to validate the PICT pretest predictions, and the effectiveness of the secondary flow controller on reactor inlet temperature and turbine pressure controls will be discussed.

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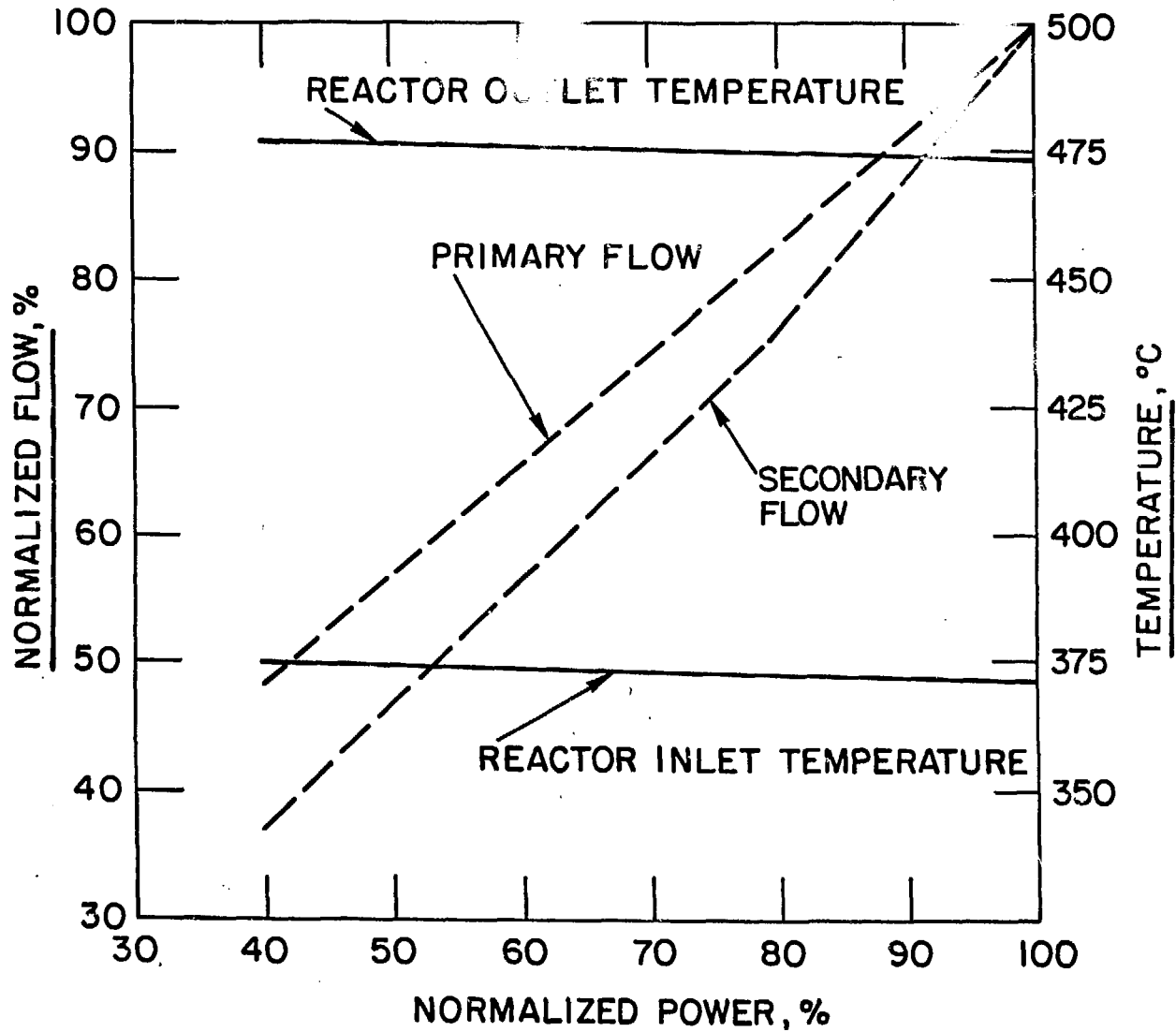


Figure 1. Reactor Power Control Using Primary Flow and Reactor Inlet Temperature