

Inherent Accommodation of Unprotected
Loss-of-Flow Accidents in LMFBRs*

by

S. F. Su and R. H. Sevy

NOTICE

**PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
has been reproduced from the best available
copy to permit the broadest possible avail-
ability.**

Inherent safety is a major focus of attention in fast reactor design. Extensive efforts have been given to utilizing intrinsic characteristics of sodium-cooled reactors to enhance the plant's ability to accommodate even the most unlikely accidents, such as loss-of-flow (LOF) with failure to scram. The renewed interest in the pool concept partially reflects this new direction. The reintroduction of metal fuel also opens a new frontier for fast reactor safety technology. This study explores the potential of the metal fuel in achieving designs which are inherently safe against unprotected LOF accidents. The study is conducted using the SASSYS code¹ and is based on an 1000 MWe pool design.²

In an earlier study³ involving the oxide fuel, we found that during the LOF accident, control rod drive elongation and radial core expansion induced by the increasing coolant temperature can generate enough negative feedback to cause the power to decrease. However, a strong resistance to power decline is present, particularly in the form of the positive Doppler, and axial fuel contraction feedbacks. The large Doppler and axial fuel contraction feedbacks arise from the low thermal conductivity of the oxide fuel, which during normal operations is responsible for a large fuel temperature gradient across of the fuel pin. As the power decreases in response to reactivity feedbacks, collapse of this gradient causes a substantial drop in the average fuel temperature and thus introduces large fuel temperature feedbacks. Shutdown by intrinsic feedbacks is therefore significantly impeded. Although under certain conditions,

*Work performed under the auspices of the U.S. Department of Energy.

MASTER
EAB

including an extended flow coastdown, coolant boiling possibly can be avoided, the margin to boiling is very small and may not be able to accommodate uncertainties in reactivity feedbacks.

The high thermal conductivity of the metal fuel, along with the high thermal conductance of the sodium bond, minimizes the positive fuel temperature feedbacks and allows the power to descend more rapidly. Coolant temperature rise is substantially reduced. Figure 1 shows the reactivity, power and coolant temperature histories of a LOF without scram accident for both metal and oxide fuels. The maximum coolant temperature rise for the metal fuel is only 120°C, while the oxide core will approach boiling at 1000 s after the temperature has risen 400°C.

The temperature of the metal fuel can even increase during a severe transient in which the coolant temperature rise exceeds the collapse of the fuel temperature gradient in the pin. Under such circumstances, the fuel temperature feedbacks will become negative, and will assist in forcing the power to decrease. For cores with a low sodium void reactivity the fuel temperature feedbacks, uncomplimented by the rod and core expansion feedbacks, can actually prevent coolant from reaching the critical temperature. A metal core is therefore very tolerant of feedback uncertainties. The substantial safety margins offered by the metal fuel will probably eliminate the need for an extended flow coastdown.

In a prolonged, concurrent loss-of-flow/loss-of-heat-sink (LOHS) accident with failure to scram, the coolant temperature of the metal core will remain low in the first 5 hours. During that period, the power will descend to a level (<1%) that can be ejected by shutdown heat removal systems. If these heat removal systems are also lost, there are approximately 15 hours available for corrective actions. Considering the severity and unlikelihood of the

accident, this grace period is very long and is due to the power limiting reactivity feedbacks, and the large heat sink of the pool. The core is coolable by natural circulation or pony motor flow.

The metal core can also survive a coupled unscrammed loss-of-flow/transient-overpower accident if the reactivity inserted does not exceed about 50¢. However, this is contingent on an extended flow coastdown and on a step reactivity introduced at the onset of the flow loss; more studies are required to see whether different timings of events can lead to more severe consequences.

REFERENCES

1. F. E. Dunn and F. G. Prohammer, "SASSYS Analysis of Degraded Shutdown Heat Removal Performance in LMFBRs," presented at ASME 103rd Winter Annual Meeting, Paper #82-WA/HT-37, November 14-19, 1983, Phoenix, Arizona.
2. Y. I. Chang, private communication, July 1982.
3. S. F. Su, R. H. Sevy to Y. I. Chang, unpublished data, December 1982.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

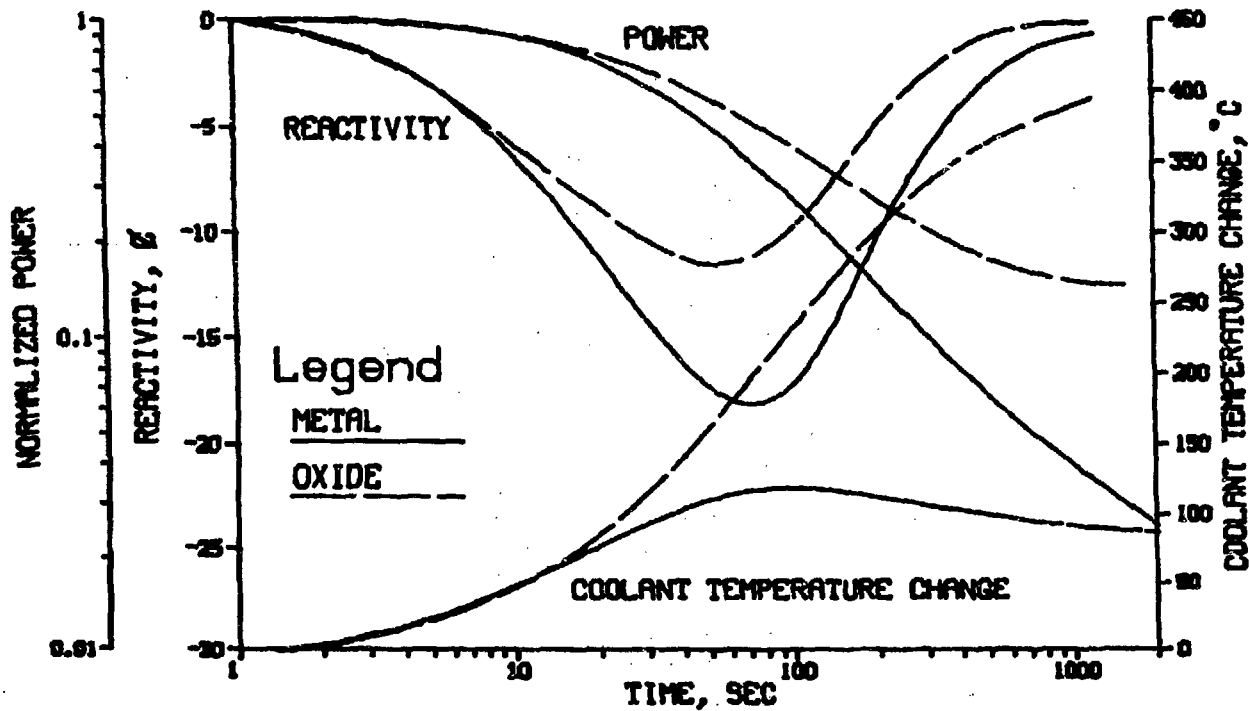


Fig. 1. Changes in Reactivity, Power, and Coolant Temperature During a Loss-of-Flow Without Scram Accident