CONCEPTS OF REMOTE SIGNAL TRANSMISSION FOR LIQUID-METAL FAST BREEDER REACTORS

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Remote signal transmission (RST) for core variables of liquid-metal fast breeder reactors ideally implies a sensing of the variable and a wireless transmission of its value to a receiver or receivers external to the reactor primary containment vessel. It has received limited consideration because of uncertainties in its need and practicability of its implementation. Many reactor designers in this country believe that out-of-core instrumentation can be designed to reduce the impact of credible core accident to a level that will not affect the integrity of the primary containment.

However, some advantages of sensors closely coupled to core variables are apparent. An early awareness of abnormal conditions in the reactor core could help prevent major damage and costly clean up and repair. Operation closer to limits of safety may be possible, resulting in higher efficiencies and a reduction in operating costs. Also, instrumentation of this type may be desirable for the first liquid-metal fast breeder reactors (such as the demonstration unit) to help verify the core design calculations. This monitoring instrumentation, initially committed to a surveillance system, might be expanded to operate control and protective systems as they are developed to yield greater reliability.

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To be most effective, in-core instrumentation should monitor each fuel assembly and should not interfere with the core-loading procedure or reactor control operation. This becomes a formidable problem when one considers that a liquid-metal fast breeder reactor (LMFBR) core will contain over 200 fuel assemblies. It therefore may be necessary to deviate from the ideal RST concept by multiplexing with a minimal number of reactor vessel penetrations.\textsuperscript{1,2}

From a detailed survey of the literature,\textsuperscript{3} we have identified sensors and signal transmission techniques which might withstand the temperature (300 to 700°C) and nuclear radiation ($10^{11}$ to $10^{13}$ nu fast neutron flux, $10^5$ to $10^7$ R/hr gamma dose rate) of the liquid-metal fast breeder environment for a minimum life-time of one year. In our judgment there are a few approaches which have a reasonable probability of achieving most of the goals of RST and a very high probability of success in less stringent applications such as wireless monitors for initial core loading and fuel reloading.

Pulse-echo (sonar) techniques utilizing the technology developed for under-sodium viewing can detect changes in the density of sodium or changes in the position of surfaces in response to core variables at distances of up to 6 meters.\textsuperscript{4,5} Fluidic oscillators based on a rapidly developing fluidic technology can sense and control parameters of liquid and gaseous media. Because of their simplicity (no moving parts) these devices are especially useful in extremes of temperature, vibration and nuclear radiation with their limit of operation determined solely by the dimensional stability of their structural material. Existing electronic components and some which are in the final stages of development for geothermal
instrumentation are potentially useful for versatile electronic circuits which can amplify and transmit signals from in-core sensors.

Some of the major problems which must be addressed are the achievement of a line-of-sight access to the core, the development of sodium-immersible transducers for operation in a fast neutron fluence in excess of $10^{18}$ nvt, the development of multiplexing schemes to offset the limited number of operating frequencies for fluidic oscillators, the development of compact high temperature circuitry with power supplies and developmental costs which are expected to be particularly high for in-core electronic circuits.
REFERENCES


