IDENTIFICATION OF NEUTRON NOISE SOURCES IN A BOILING WATER REACTOR*

W. H. Sides, Jr.
M. V. Mathis**

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

CONF-771109--64

Measurements were made at Units 2 and 3 of the TVA Browns Ferry nuclear power plant in order to characterize the neutron and process signal noise signatures, to determine the degree of correlation between selected pairs of signals, and to assess the usefulness of such signatures for monitoring and anomaly detection in BWR-4s. Measurements were made in a power plant during normal operation at full power to determine the usefulness of the neutron and process signals from sensors and instrumentation in the plant which have been contaminated by plant electrical noise interference. The signals from eleven local-power-range monitors (LPRMs), from average-power-range monitors (APRMs; the average of ∿20 LPRM detector signals), and from fifteen process sensors were recorded by a fourteen-channel, FM tape recorder.

The process signals included core, driver, jet pump, feedwater and steam flows, reactor pressure, core differential pressure, and reactor water level. The recorded signals were taken from the plant startup and at-power test panels; the existing plant signal amplification and conditioning equipment was used. To obtain sufficient statistical precision, several data sets, each 4 hr long, were recorded.

*Research sponsored by the Energy Research and Development Administration under contract with the Union Carbide Corporation.

**Presently employed at the Technology for Energy Corporation (TEC), Knoxville, Tennessee.

The recorded data were Fourier analyzed in the frequency range from 0.01 to 2 Hz. The principal descriptor used in the analysis of the data was the coherence function. Particular attention was given to determining the coherence between LPRM and APRM signals, between pairs of LPRM signals, and between the process signals and an APRM signal. The coherence functions between the LPRM signals and an APRM signal showed a consistent, high coherence in the frequency range from 0.1 to 1.0 Hz, with a maximum near 0.5 Hz. This resonance has been measured by others and identified as dependent on the stability of the core.[1] In the frequency range from 0.01 to 0.1 Hz, the Unit 3 results showed high coherence for detectors near the center of the core, with decreasing coherence in this range for detectors near the core edge. However, in Unit 2, the coherence of detector signals in this frequency range did not decrease as much from core center to core edge as did the coherence of signals in Unit 3. This result may be related to differences in flow patterns in the two units, but further analysis and comparisons with model calculations are needed to determine whether this is correct. Pairs of LPRM signals show a high coherence between signals from adjacent LPRM detectors in the same flow channel and a lesser coherence between signals from detectors in different flow channels — an observation of previous investigators as well.[2,3]

Analysis of the APRM and process noise signals indicated a significant coherence (>0.6) between neutron noise signals from the APRM and the following process signals: core flow, reactor pressure, core differential pressure, and total steam flow. The coherence was negligible between the APRM and driver flow, individual jet pump flow, feedwater flow, and reactor water level. In the frequency range from 0.01 to 0.1 Hz, the coherence values between process signals were 0.4 to 0.6

among the core flow, pressure, differential pressure, and steam flow signals, but the coherence between these signals was negligible in the range from 0.1 to 1 Hz.

Based on these observed coherence results, we conclude that the signals derived from existing plant sensors and instrumentation could be used to diagnose anomalies. The neutron signals could be used to monitor the stability of the core and to diagnose anomalies involving the reactor pressure, core flow, and steam flow. These signals could also be used to verify predictions of a BWR mathematical model. We further conclude that such process signals as driver flow, individual jet pump flow, feedwater flow, and reactor water level were not sufficiently correlated with the neutron signals to allow useful monitoring of these variables with the neutron signals.

ACKNOWLEDGMENTS

The authors acknowledges the valuable assistance of M. L. Dailey of TVA and O. C. Cole and C. O. McNew of ORNL in completing this work.

REFERENCES

1. Tsutomu Nomura, "BWR Noise Spectra and Applications of Noise Analysis to FBR," *Annals Nucl. Ener.* 2, 379-389 (1975).

2. Y. Ando et al., "Void Detection in a BWR By Noise Analysis," *J. Nucl. Sci. Technol.* 12(9), 597-599 (September 1975).

3. D. N. Fry et al., "Core Component Vibration Monitoring in BWRs Using Neutron Noise," *Trans. Amer. Nucl. Soc.* 22(1), 623 (November 1975).