

CONF-871006--1

A PORTABLE MEASUREMENT SYSTEM FOR SUBCRITICALITY MEASUREMENTS BY THE CF-SOURCE-DRIVEN NEUTRON NOISE ANALYSIS METHOD

The submitted manuscript has been authored by a contractor of the U.S. Government under contract No. DE-AC05-84OR21400. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

J. T. Mihalczo
G. E. Ragan
E. D. Blakeman

CONF-871006--1

DE88 001413

Instrumentation and Controls Division
Oak Ridge National Laboratory*
Post Box X, Oak Ridge, Tennessee 37831-6010

A portable measurement system consisting of a personal computer used as a Fourier analyzer and three detection channels (with associated electronics that provide the signals to analog-to-digital (A/D) converters) has been assembled to measure subcriticality by the ²⁵²Cf-source-driven neutron noise analysis method.¹

The ²⁵²Cf-source-driven neutron noise analysis method for obtaining the subcritical neutron multiplication factor of a configuration of fissile material requires measurement of the frequency-dependent cross-power spectral density (CPSD), $G_{12}(\omega)$, between a pair of detectors (Nos. 2 and 3) located in or near the fissile material and CPSDs $G_{11}(\omega)$ and $G_{33}(\omega)$ between these same detectors and a source of neutrons emanating from an ionization chamber (No. 1) containing ²⁵²Cf, also positioned in or near the fissile material. The auto-power spectral density (APSD), $G_{11}(\omega)$, of the source is also required. A particular ratio of spectral densities, $G_{12}^*G_{33}/G_{11}G_{22}$ (* denotes complex conjugation), is then formed. This ratio is related to the subcritical neutron multiplication factor and is independent of detector efficiencies.¹

The portable measurement system (Fig. 1) consists of a parallel-plate ionization chamber containing ²⁵²Cf, two ³He proportional counters and their associated electronics, and a small computer containing anti-aliasing filters and A/D converters. The system Fourier analyzes the digitized data and forms the appropriate APSD and CPSDs. These spectra are used to form the ratio, $G_{12}^*G_{33}/G_{11}G_{22}$, from which the subcriticality can be determined. The system is capable of sampling signals at rates up to 80 kHz and processing these data at rates (to form the appropriate spectra) of 2 kHz. As presently configured, it is a two-channel system requiring that measurement of G_{11} , G_{33} , and G_{22} be done sequentially before the ratio of spectral densities is calculated.

The appropriate signals from an ionization chamber containing ²⁵²Cf and a pair of detectors placed near a submerged (in water) High Flux Isotope Reactor fuel element were recorded on an FM instrumentation grade tape recorder. The signals were analyzed on line with a large commercially available HP 5451 four-channel Fourier analyzer. After the experiment the data recorded on tape were analyzed by the portable system. Pairs of channels were sampled sequentially for ~20 minutes by the portable system and the cross power spectral densities G_{12} , G_{13} , G_{23} , and the auto power spectral density G_{11} obtained. The magnitudes of the spectral densities and the ratio of spectral densities as a function of frequency obtained by the portable system

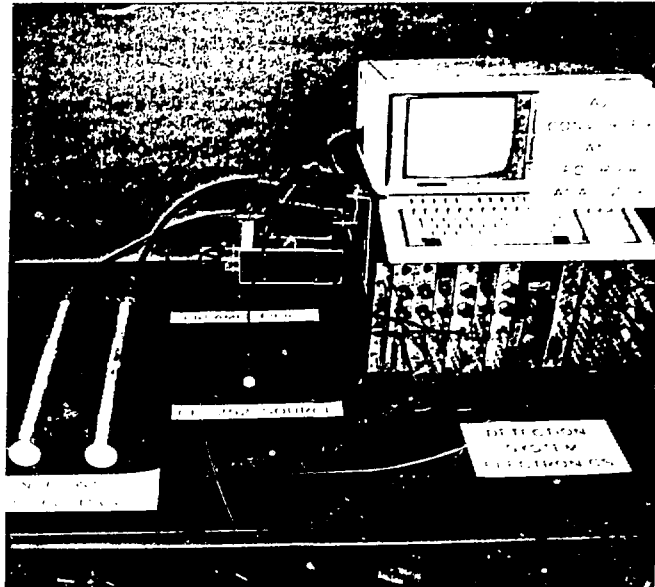


Fig. 1. Portable measurement system.

are shown in Fig. 2 and 3. The ratio of spectral densities averaged up to 300 Hz was 0.0623 ± 0.0013 and agreed with the value from the large commercial Fourier Analyzer, 0.0618 ± 0.0008 .

The development of a portable measurement system makes the application of this method more practicable. Future improvements of the system will allow simultaneous measurements of all spectra while retaining portability. Further reductions in size and increased portability could be achieved with a special-purpose computer design.

Some of the potential applications of this method for which experiments have been performed and the usefulness of the method demonstrated are (1) initial fuel loading of reactors,¹ (2) refueling of reactors,² (3) fuel-preparation facilities,³ (4) fuel-processing facilities,³ (5) fuel-storage facilities,⁴ (6) zero-power testing of reactors,⁵ and (7) verification of calculational methods for assemblies with $k_{eff} < 1$.⁶ In these experiments, the subcritical neutron multiplication factors, k_{eff} , were determined for systems whose k_{eff} values varied from -0.5 to -0.99 utilizing a large, elaborate research measurement system. The portable system is capable of measuring a variety of fissile systems conveniently, and at a relatively low cost.

*Operated by Martin Marietta Energy Systems, Inc. for the U.S. Department of Energy under contract No. DE-AC05-84OR21400.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

gsw

SPECTRAL DENSITIES VS FREQUENCY

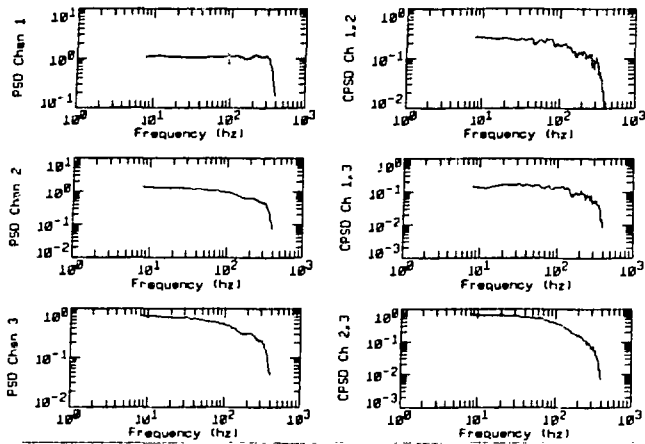


Fig. 2. Plots of magnitudes of spectral densities for HFIR core 251.

SPECTRAL RATIO VS FREQUENCY

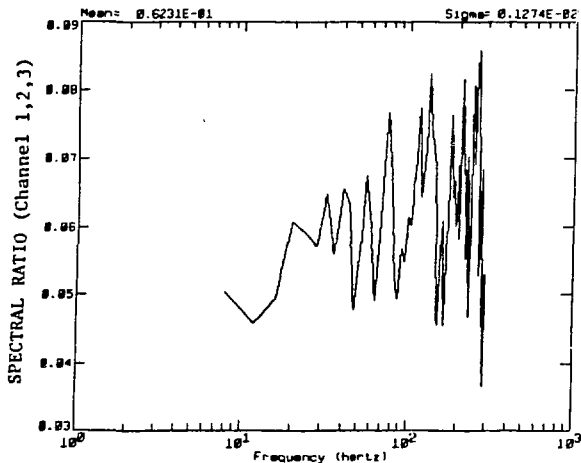


Fig. 3. Ratio of spectral densities for HFIR core 251.

REFERENCES

- [1] J. T. Mihalcz, V. K. Pare, G. L. Ragan, M. V. Mathis, and G. C. Tillett, "Determination of Reactivity from Power Spectral Density Measurements with ^{252}Cf ," *Nucl. Sci. Eng.* **60**, 29 (1978).
- [2] W. T. King, J. T. Mihalcz, and E. D. Blakeman, "Preliminary Investigation of the ^{252}Cf -Source-Driven Noise Analysis Method of Subcriticality Measurements in LWR Fuel Storage and Initial Loading Applications," *Trans. Am. Nucl. Soc.* **47**, 238 (1984).
- [3] J. T. Mihalcz and W. T. King, " ^{252}Cf -Source-Driven Noise Method for Measuring Subcriticality of Submerged HFIR Fuel Elements," *Trans. Am. Nucl. Soc.* **43**, 408 (1982).
- [4] J. T. Mihalcz, W. T. King, and E. D. Blakeman, "Subcriticality Measurements For Coupled Uranium Metal Cylinders Using the Cf-Source-Driven Neutron Noise Analysis Method," *Nucl. Sci. & Eng.* **95**, 1-13 (1987).
- [5] J. T. Mihalcz, W. T. King, E. B. Johnson, and E. D. Blakeman, "Subcriticality Measurements For a Fuel Solution Tank with Changing Fuel Concentration Using ^{252}Cf -Source-Driven Neutron Noise Analysis," *Trans. Am. Nucl. Soc.* **45**, 37 (1983).
- [6] J. T. Mihalcz, W. T. King, and E. D. Blakeman, "Decoupling of Uranium Metal with Borated Plaster Using ^{252}Cf Noise Analysis Methods," *Trans. Am. Nucl. Soc.* **50**, 307-309 (1985).
- [7] W. T. King and J. T. Mihalcz, "Power Spectral Density Measurements with ^{252}Cf for a Light-Water-Moderated Research Reactor," *Trans. Am. Nucl. Soc.* **33**, 796 (1979).
- [8] J. T. Mihalcz, R. C. Kryter, W. T. King, and E. D. Blakeman, *Ann. Nucl. Energy* **V**, 1-13, No. 7, pp. 351-62 (1986).

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.