CONF 871005--1

CONF-871005--1

DE87 008592

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

J. T. Mihalczo
G. E. Ragan

Instrumentation and Controls Division
Oak Ridge National Laboratory*
Oak Ridge, Tennessee 37831

Paper Submitted For Presentation At IEEE
Nuclear Science Symposium, Oct. 21-23, 1987
San Francisco, California.

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

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

J. T. Mihalcso and G. E. Ragan

A portable system has been assembled that is capable of measuring the subcriticality of fissile materials using the ^{252}CF-source-driven neutron noise analysis method. The measurement system consists of a parallel-plate ionisation chamber containing ^{252}CF, two ^{3}He proportional counters with their associated electronics, and a small computer containing anti-aliasing filters and A/D convertors. The system Fourier analyses the digitised data and forms the appropriate auto and cross-power spectral densities. These spectra are used to form a ratio of spectral densities, $G_{12}^{*} G_{13}/G_{11} G_{23}$, where 1 refers to the ionisation chamber, and 2 and 3 refer to the ^{3}He counters, from which subcriticality can be determined. The chamber and detectors are located appropriately near the fissile material. The system is capable of sampling signals at rates of up to 80 kHs and processing these data at rates of 2 kHs to form the appropriate spectra. The presently configured system is a two-channel system, hence the measurement of G_{12}, G_{13}, and G_{23} must be done sequentially before the ratio of spectral densities is obtained. Future improvements of the system will allow simultaneous measurement of all spectra and will further reduce sise, thereby enhancing portability. This measurement system can provide reliable, cost effective, and convenient determination of the subcriticality of a wide variety of fissile materials and moderators.

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

J. T. Mihalczo

G. E. Ragan

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) convertors) has been assembled to measure subcriticality by the ^{252}Cf-source-driven neutron noise analysis method.[1]

The ^{252}Cf-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), $G_{23}(\omega)$, between a pair of detectors (Nos. 2 and 3) located in or near the fissile material and CPSDs $G_{12}(\omega)$ and $G_{13}(\omega)$ between these same detectors and a source of neutrons emanating from an ionization chamber (No. 1) containing ^{252}Cf, 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, $G^*_{12}G_{13}/G_{11}G_{23}$ (* denotes complex conjugation), is then formed. This ratio is related to the subcritical neutron multiplication factor and is independent of detector efficiencies.

The portable measurement system (Fig. 1) consists of a parallel-plate ionization chamber containing ^{252}Cf, two ^3He proportional counters and their associated electronics, and a small computer containing anti-aliasing filters and A/D convertors. The system Fourier analyzes the digitized data and forms the appropriate APSD and CPSDs. These spectra are used to form the ratio, $G^*_{12}G_{13}/G_{11}G_{23}$, 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_{12}, G_{13}, and G_{23} be done sequentially before the ratio of spectral densities is calculated. Future improvements of the system will allow simultaneous measurement of all spectra while retaining portability. Further reductions in size and increased portability could be achieved with a special-purpose computer design.

The development of a portable measurement system makes the application of this method more practicable. 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,[2] (2) refueling of reactors,[3] (3) fuel-preparation facilities,[4] (4) fuel-processing facilities,[5] (5) fuel-storage facilities,[6] (6) zero-power testing of reactors,[7] and (7) verification of calculational methods for assemblies with $k_{eff} < 1$.[8] 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.

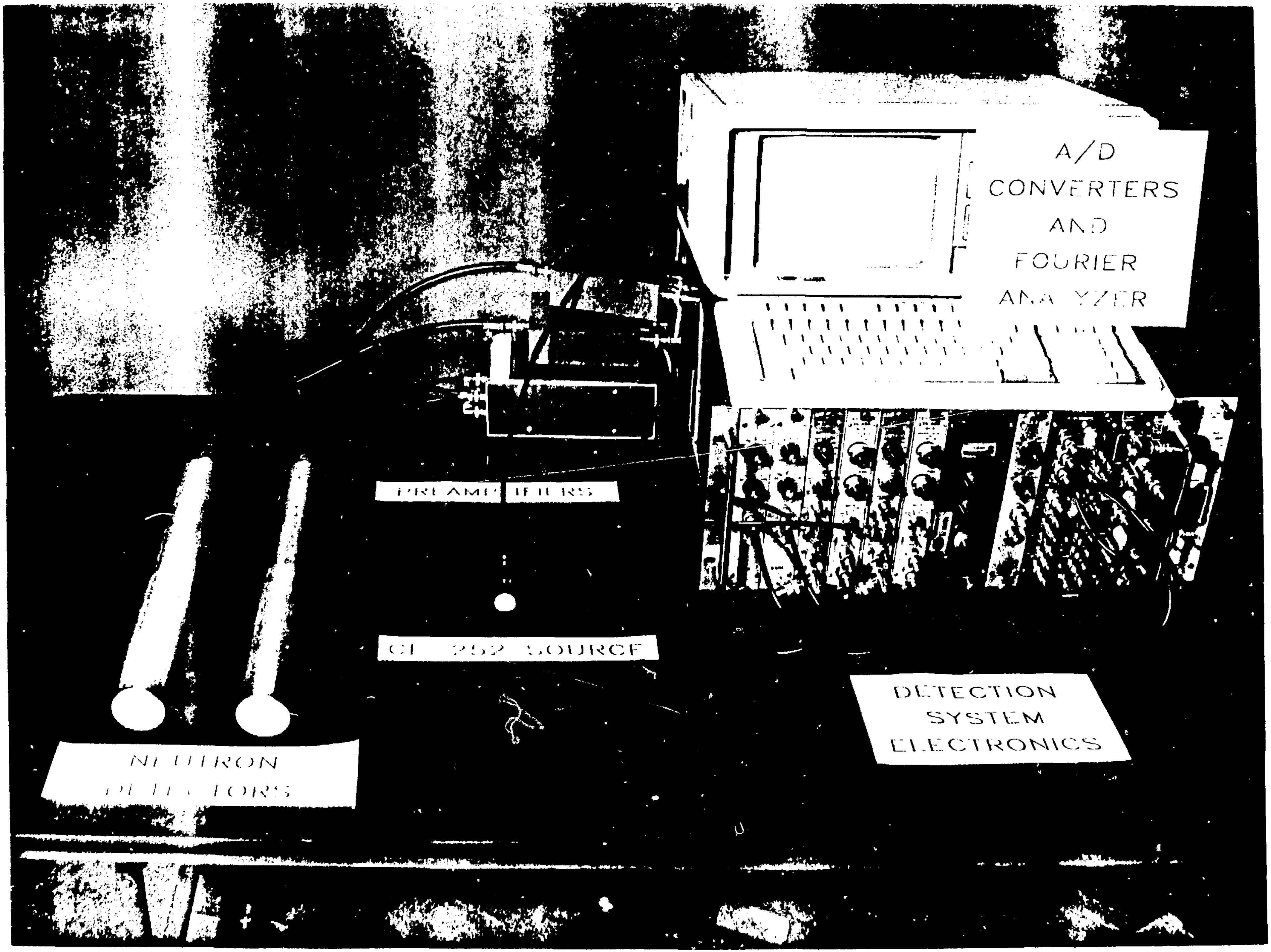

Fig. 1 Subcriticality Reactivity Measurement System

REFERENCES

1. J. T. Mihalczo, 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. Mihalczo, 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. Mihalczo 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. Mihalczo, 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. Mihalczo, 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. Mihalzo, 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. Mihalczo, "Power Spectral Density Measurements with ^{252}Cf for a Light-Water-Moderated Research Reactor," Trans. Am. Nucl. Soc. 33, 796 (1979).

8. J. T. Mihalczo, R. C. Kryter, W. T. King, and E. D. Blakeman, Ann. Nucl. Energy V, 1-13, No. 7, pp. 351-62 (1986).