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A LOW LEVEL NEUTRON FLUX MONITORING SYSTEM FOR LMFBR's*

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A low level neutron flux monitoring (LLFM) system for use in LMFBR's while operating in the source range must function in an extremely hostile environment of liquid sodium and of high temperature, gamma radiation, and electromagnetic noise levels since in-vessel neutron detectors must be employed. Preliminary testing of LLFM systems for use in such environments have been reported by several researchers.^{1,2} The purpose of this paper is to report on further testing of an LLFM system under simulated LMFBR conditions and the first successful in-vessel operation of an LLFM system in an LMFBR type reactor, the SEFOR.

As part of the experimental effort of the ORNL development program on subcriticality measurement systems for LMFBR's, an LLFM system has been developed and tested. The expected environmental conditions of the FFTF LLFM system were chosen as the design goals of the ORNL system: in particular, a temperature of 350°F and a gamma field of 10⁶ R/h.

Our LLFM system comprises a ²³⁵U fission counter, a high temperature connector and cable assembly, a low-noise preamplifier operated in the current mode, pulse shaping and amplification circuits, a pulse height discriminator, and a 100 MHz scaler. The fission counter is a Reuter Stokes model RSN-10A with two modifications: (1) a 95% Ar + 5% CO₂ gas filling of 1 atm to give a faster pulse collection time (80 nsec) and (2) a 99.9% ²³⁵U coating of 2.0 mg/cm² for an increased neutron sensitivity and a reduced ²³⁴U alpha

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background. A Reuter Stokes connector, model J-3127K-00, is used as the high temperature connector. The high temperature cable is a modified Sante-Fe model SF-388 cable. A triple Cu braid shield is used to improve the electrical shield performance over that of the normal single braid shield. Furthermore a single Cu braid, electrically isolated from the triple braid primary shield, is used as a secondary electrical shield. The primary shield is connected to the high-quality instrumentation ground whereas the secondary shield is connected to the "dirty" building ground. The preamplifier, ORNL Q-5095-1, is a type BG model fabricated according to RDT Standard C15-3T.³ 27 nsec integrating and differentiating time constants are used with standard commercial pulse amplifiers, discriminator, and scaler.

Extensive laboratory testing of the system was performed under simulated LMFBR conditions. The detector, connector, and cable (first five feet) were tested in a furnace at 400°F continuously for 30 days followed by considerable thermal cycling. Neither temperature pulse breakdown noise nor degradation in neutron integral bias curve or neutron pulse amplitude and width were detected throughout the temperature tests.

Gamma discrimination tests on the LLFM system were performed using spent fuel elements from the High Flux Isotope Reactor to produce the gamma levels desired. The system performed adequately at 10^6 R/h and marginally up to 10^7 R/h.

The final test of the LLFM system was successfully performed as part of subcriticality measurement experiment in the SEFOR. Two separate identical detection systems were tested in the experiment. The two detectors and cables, in a stainless steel drywell lined with .275 in. of Pb, were inserted in the center of the SEFOR core after a power run. The

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liquid sodium ambient temperature was 350°F. The gamma level was determined to be 0.7×10^6 R/h. Certainly the electromagnetic noise background was representative of an LMFBR. The LLFM system demonstrated excellent performance in the SEFOR. Only an eight percent loss in effective neutron sensitivity was required to discriminate against the gamma background. The LLFM system received 10 days of testing in the SEFOR, and no degradation in system characteristics (integral bias curve or pulse amplitude and collection time) were detected. Also no electromagnetic noise pulse were recorded in numerous 500 sec background counts at the operating PHS level demonstrating adequate electrical noise rejection characteristics.

In conclusion we have developed and tested an LLFM system for use in an LMFBR. Through testing in the SEFOR, we have demonstrated the successful performance of this system in an environment similar to that expected in the FFTF.

References

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