ANALYSIS OF NEUTRON-DENSITY OSCILLATIONS RESULTING
FROM CORE BARREL MOTION IN A PWR NUCLEAR POWER PLANT*

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At the request of the U. S. Atomic Energy Commission, the authors investigated unusual neutronic noise at the Palisades Nuclear Plant in late July, 1973. Previously the plant operator, Consumers Power Company (CPCO), and the plant designer, Combustion Engineering (CE), had observed abnormal flux oscillations on the output from ex-core detectors in the plant, had investigated and characterized the signals with noise analysis techniques, and had speculated that the oscillations resulted from flow-induced motion of the reactor core barrel. On-site noise diagnosis by ORNL of plant signals such as in-core and ex-core neutron flux, temperature, and vibrations (sensed by ex-vessel accelerometers) with the aid of a computer-based noise analyzer substantiated the previous conclusions of CPCO and CE: the abnormal ex-core detector flux oscillations were attributable to changes in neutron leakage to these detectors caused by a rocking motion of the core barrel and core as a unit inside the pressure vessel.

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Following the on-site measurements, an analog magnetic-tape recording of plant neutron detector signals was obtained from CE so that an in-depth study could be conducted at ORNL. Shortly thereafter, while Palisades was shut down for inspection of the steam generator, the reactor pressure vessel internals were visually inspected to confirm the noise analysis diagnosis that the core barrel had rocked during operation. The inspection revealed that an ~ 0.25 in. thickness of metal had worn from the mating surfaces of the core support barrel flange and pressure vessel and that all fasteners holding the expansion-compensating ring in position were broken,¹ thus confirming the speculated mode of motion.

Our objectives in reporting this work are to (1) show the advantage of using a variety of plant signals, each processed statistically in several ways, in performing unambiguous diagnoses; and (2) illustrate the reasoning by which an investigator can assimilate the various complementary pieces of information to diagnose the performance of reactor internals. We stress the need for presentation of experimental results in absolute, universally recognized units of measurement so that they will be amenable to comparison with both theoretical analyses and measurements from other plants of similar construction.

Some of the more important observations of the Palisades study² were as follows:

1. In-core detector rms noise was ~ 4 times smaller than ex-core noise in the 0.03-5 Hz range. From this observation, we concluded that the cause of the larger ex-core noise was not due to power fluctuations.
2. Some ex-core detectors had considerably higher rms noise levels in the 0.03-5 Hz range than others. Furthermore, the relative phase shift among ex-core detectors varied from 0 to 180° with detector circumferential position. These facts indicate

a preferred direction of motion.

3. The amplitude distributions of the ex-core detectors were not symmetric with respect to their mean values, i.e., fluctuations in signal amplitude had a preferred sign.

This fact reinforces other indications of preferentially oriented core barrel rocking.

We believe that the neutron noise signatures associated with the movement of the core barrel in this PWR will be helpful in diagnosing similar abnormalities if they occur in other PWRs.

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References

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