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Noise analysis of ex-core power range channel signals has been developed, through experimental[1–4] and analytical[5] efforts, to a point where it is recognized by both PWR manufacturers and the Nuclear Regulatory Commission[6] to provide a basis for nonperturbative inservice monitoring for excessive or altered mechanical motion of the reactor core support barrel which might be indicative of degraded structural integrity. Data recently acquired at two similar (sister) PWR plants and reported herein further confirm the sensitivity and workability of the noise analysis technique, but also emphasize the need for careful selection of neutron signal passbandwidth if correct results are to be obtained.

Technical Specifications regulating the acquisition and processing of core barrel motion data from certain PWR plants currently call for amplitude probability density (APD) and/or root mean square (RMS) measurements derived from the power range channels over an <u>unspecified</u> frequency bandwidth. It is a foregone conclusion that if the contributions of noise sources unrelated to core support barrel motion are not properly eliminated, then an incorrect estimate of motional amplitude will be inferred; however, we believe that the present work is the first to assess the probable magnitude of the resultant error.

To quantify the effects of signal bandwidth, we recorded ex-core neutron detector signals at two sister PWR plants having slightly different (but both acceptably small) core barrel motions and analyzed their content over several frequency ranges. These data were recorded early in the initial startup testing phase of the plants (referred to hereafter as Unit I and Unit II), even before full commercial operating power had been attained. Tables 1 and 2 compare both the peak displacements (from the APD functions) and the RMS displacements [from the auto-power spectral density (PSD) functions and from the magnitudes of the cross-power spectral density (CPSD) functions] inferred using a data-scaling factor[5] of 0.01% fractional change in ionization chamber reaction rate per mil (10^{-3} inch) of barrel movement. In each table, the first frequency band listed is the "preferred" one (i.e., it was selected to span the natural beam-mode resonant frequency of the core support barrel, as installed, with normal clamping force applied), the last frequency band listed is the essentially unrestricted interval commonly employed at plants subject to the insufficiently detailed Technical Specifications referred to previously, and the intermediate entries represent modest bidirectional extensions of the preferred bandwidths, as selected by the authors for comparisons purposes only.

The obvious conclusion from Tables 1 and 2 is that inferred displacements can be a factor of ten to thirty too large if the neutron signal bandwidth is not correctly limited to that frequency region where core barrel motion constitutes the dominant source of fluctuations. Very low frequencies seem to be the chief source of contamination in the present instances. Further analysis and comparison to other plant process signals showed, in fact, that at frequencies $\leq$ 5 Hz (Unit I) and $\leq$ 2 Hz (Unit II) the ionization chamber signals were strongly perturbed by occasional control rod actions (Unit I) and by an "untuned" feedwater controller (Unit II) which tended to oscillate at a frequency of $\sim$ 0.16 Hz. Additional conclusions drawn from this work are:

1. Modest extensions to the preferred (beam-mode resonance) frequency bandwidth are not likely to produce significant error in the magnitude of inferred barrel motion;
2. PSD and |CPSD| methods yield approximately the same results, even though the latter statistical descriptor has a potential capability for eliminating noise sources not common to both neutron detector channels that the PSD does not have;
3. APD and RMS methods yield consistent results if applied to the same frequency bandwidth and, when interpreted jointly (as a crest factor), provide a measure of the randomness of the orbit traversed by the core support barrel.

TABLE 1. Inferred Displacements for Unit I

Frequency Band (Hz)	Comment	Peak Displacement (mils)	Root-Mean-Square Displacement (mils)	
			PSD	|CPSD|
7.5-12.5	preferred bandwidth	2.0	0.44	0.50
5.5-9.5	3/4 of preferred		0.44	0.47
2.0-9.5	extended lower limit		1.1	0.55
2.0-15.0	extended upper limit		1.1	0.64
0.2-25.0	wideband		5.5	5.0
0.015-25.0	Tech Specs	55.0		

TABLE 2. Inferred Displacements for Unit II

Frequency Band (Hz)	Comment	Peak Displacement (mils)	Root-Mean-Square Displacement (mils)	
			PSD	|CPSD|
6.75-11.25	preferred bandwidth	6.0	1.4	1.7
5.0-8.5	3/4 of preferred		1.1	1.3
2.0-8.5	extended lower limit		1.5	1.5
2.0-15.0	extended upper limit		1.9	2.1
0.2-25.0	wideband		19.0	22.0
0.015-25.0	Tech Specs	46.0		

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