

2 October 1979

CRITERIA FOR COMBINATIONS OF EARTHQUAKE
AND/OR OTHER TRANSIENT RESPONSES

N. M. NEWMARK
R. P. KENNEDY

Preamble.

The intent of the methods proposed for combinations of transient, dynamic responses is to achieve a non-exceedance probability of approximately 84 percent for the peak combined response of the system, component, or element considered. This goal is achieved by compliance with any one of the following criteria, or any alternative method that meets the intent stated above, provided that the intensity of loads or accelerations for each input are conservatively represented (approximately at the level of the 84th percentile, or the mean plus one standard deviation, of the expected input intensity).

1. Criterion.

Dynamic or transient responses of structures, components and equipment arising from combinations of dynamic loading or motions may be combined by SRSS provided that each of the dynamic inputs or responses has characteristics similar to those of earthquake ground motions, and that the individual component inputs can be considered to be relatively uncorrelated; i.e., the individual dynamic inputs or responses considered are either from independent events or have random peak phasing. This similarity involves a limited number of peaks of force or acceleration (not more than 5 exceeding 75 percent of the maximum, or not more than 10 exceeding 60 percent of the maximum), with approximately zero mean and a total duration of strong motion (i.e., exceeding 50 percent of the maximum) of 10 seconds or less.

Explanation.

Since earthquake motions in various directions produce responses which are combined conservatively by the use of SRSS, the descriptions of dynamic or transient inputs are based on those applicable to earthquake motions. The coefficient of correlation for those is less than 0.4, and the pattern of peaks is based on Table 2 of Circular 672 of the USGS describing earthquake ground motions for use in the design of the Alaska Oil Pipeline. The probability distribution for the responses to earthquake motions is based on the concepts underlying U. S. NRC Regulatory Guide 1.60, where the standard deviation is 30 to 40 percent of the median value.

It has been proved some decades ago that modal responses to earthquake motions may be conservatively combined by SRSS methods with the same degree of conservatism as that of the motions. If each of such responses is considered to be at the level of mean plus one standard deviation, the SRSS value is also at this level. For the same reasons, responses from the three component directions of earthquake motions may also be conservatively combined by SRSS methods.

2. Criterion.

When response time-histories are available for all multiple dynamic loadings being combined, SRSS methods may be used for peak combined response when CDF calculations, using appropriate assumptions on the range of possible time lags between the response time-histories, show the following criteria are met:

- a. There is estimated to be less than approximately a 50% conditional probability that the actual peak combined response from these conservatively defined loadings exceeds approximately the SRSS calculated peak response, and
- b. There is estimated to be less than approximately a 15% conditional probability that the actual peak combined response exceeds approximately 1.2 times the SRSS calculated peak response.

APPLICATION OF THE
NEWMARK-KENNEDY CRITERIA TO THE
BLACK FOX STATION

R. P. KENNEDY

As a result of the presentation and discussion of these criteria at the ACRS Subcommittee on Fluid Hydraulic Dynamic Effects in November, 1978, I have reviewed the basis of the criteria further and I believe a minor change to the preamble should be made. Specifically, if one were to postulate a case where the individual responses have very little variance on peak amplitude (i.e., an amplitude coefficient of variation less than about 0.2), the criteria as stated may not assure that the approximate SRSS combined response exceeds the 84th percentile non-exceedance probability even when the individual responses being combined are at least at this non-exceedance probability. I believe it to be unlikely that real transient response data will actually have such a low coefficient of variation, so that from a practical standpoint a change in the criteria is probably unnecessary. Nevertheless, for application of the criteria to the design of the Black Fox Station, I recommend the last sentence of the preamble to the criteria be revised to read:

"This goal is achieved by compliance with any one of the following criteria, or any alternative method that meets the intent stated above, provided that the intensity of loads or accelerations for each input are conservatively represented (approximately at the level of the 84th percentile, or at 1.2 times the median level, whichever is greater)."
(underscoring indicates change of language)*

* Throughout this testimony, when individual inputs are discussed as being at the 84th percentile, it is meant the inputs are at the 84th percentile or at 1.2 times the median level, whichever is greater.

This change will conservatively guard against the possible but unlikely case where there is very low variance in the individual amplitudes so that even under this highly unlikely condition, the criteria, as applied to the Black Fox Station, provide reasonable confidence that the SRSS combined response exceeds the 84th percentile when each individual response is at this percentile. I believe this recommendation is probably more conservative than necessary. Further studies are being conducted to determine the amount by which each input response must exceed the median response to assure that the SRSS combined response exceeds the 84th percentile in these cases of low dispersion on the peak amplitude. I am confident the required amount will lie between 1.05 and 1.2 times the median response and my best estimate of this amount is 1.1 times the median response level. I am certain the value need not exceed 1.2 times the median response. Thus, I recommend that this upper-bound limit of 1.2 times the median level be incorporated into the application of the criteria for Black Fox Station.

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February 5, 1979

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Re: In the Matter of the Application of)
Public Service Company of Oklahoma,)
Associated Electric Cooperative, Inc.) Docket No. STN 50-556
and) STN 50-557
Western Farmers Electric Cooperative)
(Black Fox Station, Units 1 and 2))

Gentlemen:

On September 25, 1978, Applicants filed direct testimony in this proceeding under cover of a pleading entitled, "Notice of Filing Applicants' Direct Testimony and Identification of Exhibits." On pages 3 and 4 of that pleading, Applicants noted that the NRC Staff's generic position on load combination methods was yet to be announced and, therefore, Applicants reserved the right to file additional direct and/or rebuttal testimony on the subject.

On or about September 29, 1978, the NRC Staff filed Mr. Varga's testimony and NUREG-0484 on the subject of load combination methodology. Thereafter, Mr. Varga, by letter dated October 31, 1978 (copies were furnished to the Service List), advised Applicants of the NRC Staff's position, and requested a commitment with respect to certain aspects of NUREG-0484

Applicants commenced a review and analysis of NUREG-0484

Sheldon J. Wolfe, Esquire
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February 5, 1979

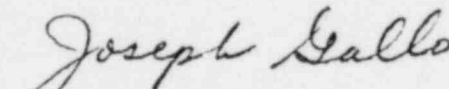
immediately upon its receipt in early October, 1978, and, among other things, employed independent consultants (Dr. Kennedy and Mr. Fuller) to assist in developing a position on the methodology issue. This effort was diligently pursued and culminated with Applicants' letter of December 20, 1978 (copies were furnished to the Service List) in reply to Mr. Varga's letter of October 31. In its letter, Applicants proposed a commitment of a somewhat different nature than that suggested by the NRC Staff. The matter was subsequently discussed in a meeting among representatives of the NRC Staff, Applicants and Intervenors in the offices of the NRC in Bethesda on January 23, 1979.

Based on Applicants' analysis of the load combination issue and the meeting with the NRC Staff, the following testimony is herewith submitted:

1. Dr. R. P. Kennedy - testifying in support of the generic use of SRSS methodology and the Newmark-Kennedy Criteria;
2. Dr. Chittoor V. Subramanian - testifying in support of the application of the Newmark-Kennedy Criteria to Mark III containment design;
3. Mr. Edward D. Fuller - testifying in support of the generic application of SRSS methodology; and
4. Mr. Vaughn L. Conrad - testifying as to the nature of Applicants' commitment.

The foregoing testimony will be offered at the resumed hearing scheduled for February 23, 1979.

Sincerely,


Joseph Gallo

One of the Attorneys for
the Applicants.

JG:ds

ccs: Service List

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