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U. S. Nuclear Regulatory Commission
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Subject: Arkansas Nuclear One - Unit 1
Docket No. 50-313
License No. DPR-51
Generic Letter 87-02, Supplement 1; Supplemental Safety Evaluation Report No. 2 on Seismic Qualification Utility Group Generic Implementation Procedure, Revision 2
(TAC No. M69426)

Gentlemen:

By NRC letter dated November 16, 1992 (0CNA119210), the Staff requested additional information concerning the Arkansas Nuclear One (ANO) Unit 1 in-structure response spectra in order to complete their review of the ANO-1 response to Generic Letter 87-02, Supplement 1 dated September 18, 1992 (0CAN099201). In ANO correspondence dated January 28, 1993 (0CAN019307), Entergy Operations provided the additional information specifically requested by the Staff. In the January 28, 1993 ANO correspondence, Entergy Operations also committed to provide additional supporting information beyond the original scope of the Staff's request for each of the six comments noted in Enclosure 3 of the November 16, 1992 NRC correspondence including further discussion of the basis for the multiplication factors used in determining the safe-shutdown earthquake response.

The purpose of this submittal is to provide the supporting information as committed in our January 28, 1993 submittal. Attachment 1 provides a response to each of the six NRC comments concerning the ANO-1 in-structure response spectra.

As indicated in the September 18, 1992 ANO correspondence, Entergy Operations committed to perform the required walkdowns during the next refueling outage, 1R11, which is currently scheduled to begin in early September of 1993. Your prompt review and notification of the acceptability of the ANO-1 in-structure response spectra is requested so that we may expeditiously continue preparations for the 1R11 walkdowns.

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If you have any further questions, please do not hesitate to contact me or my staff.

Very truly yours,

James J. Fisicaro
Director, Licensing

JJF/NBM/prg
Attachment

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Attachment 1

NRC Request for Additional Information Per Enclosure 3 of the November 16, 1992 NRC Correspondence Concerning the ANO-1 In-Structure Response Spectra

NRC Comment #1:

A lumped mass-spring-dashpot dynamic model was used to perform a soil-structure interaction analysis of the Reactor Building, Intake Structure, and Auxiliary Building. Incidentally, the FSAR states that all seismic Category I structures are founded on rock (with a very high shear wave velocity of 10,000 to 14,500 ft/sec, as shown in NUREG/CG-1429).

ANO-1 Supporting Information #1:

The soil spring modeling of ANO-1 safety related structures was performed at a time when it was not clear what level of foundation stiffness would constitute a rigid base model. The lumped mass-spring-dashpot dynamic model used to perform the soil-structure interaction (SSI) analysis of the Reactor Building, Auxiliary Building, and the Intake Structure represented the state of the art prevalent at that time and is capable of capturing the overall response of a building as well as today's sophisticated 3-D finite element model. The soil properties used in the SSI analysis of the buildings are Elastic Modulus = 0.720×10^6 psi, Poisson's Ratio = 0.18, and Shear Modulus = 0.305×10^6 psi. These properties were obtained as the result of extensive site investigations performed on three different occasions, as detailed in Section 2.6 of the ANO-1 Safety Analysis Report (SAR). They were used for the soil impedance calculation for the SSI analysis based on the best technology available at that time. Radiational damping due to the SSI effect was neglected in the analysis as discussed in Section 5.1.4.1 of the ANO-1 SAR.

NRC Comment/Request #2:

The operating-basis earthquake (OBE) and safe-shutdown earthquake (SSE) values for ANO-1 are 0.1g and 0.2g respectively in the horizontal direction, and two-thirds of these values are taken in the vertical direction. The licensee used the Housner spectrum as the ground spectra and generated a synthetic time history so that its response spectra enveloped the design response spectra. The licensee performed the seismic analyses of Category I structures using either the spectrum response or the time history methods, and prepared the floor response spectra (FRS) curves for OBE for structural damping values of 0.5, 1.0, 2.0, and 5.0. The licensee obtained the horizontal inertial forces for SSE using the FRS values shown for the Reactor Building, Auxiliary Building, and the Intake Structure by different multiplication factors, i.e., 1.4, 1.8, and 1.5, respectively. The basis for these different multiplication factors needs to be explained by the licensee. A constant multiplication factor of 2.0 has been indicated for determining the vertical inertial forces from the FRS curves for all buildings.

ANO-1 Further Explanation #2:

The construction permit for ANO-1 was accepted on the basis of utilizing a 2% damping value for the prestressed concrete containment structure and a 3% damping value for all other seismic Class 1 reinforced concrete structures, including the auxiliary building and intake structure for the OBE seismic response evaluation. A 5% damping value was used for the SSE seismic response evaluation of the above concrete structures. The fundamental frequencies of the containment structure, auxiliary building, and intake structure are estimated as 4.8, 11, and 11.5 Hz, respectively. The corresponding ratios of the input response spectra curves between the SSE and OBE at these frequencies for the pertinent damping values are estimated at 1.4 for the containment shell structure, 1.8 for the auxiliary building, and 1.5 for the intake structure.

The multiplication factors used to estimate the SSE horizontal response of a building from the OBE response spectra curve are based on the assumption generally adopted for plants of ANO-1's vintage that the building's response is primarily governed by the fundamental frequency of the building. The underlying theoretical basis for this assumption that a typical building tends to behave as a cantilever beam for which the horizontal response is generally dominated by the fundamental mode (i.e. 80% of the peak acceleration at the top of a three-story building is contributed by the fundamental mode). This approach is still used today for the design of a typical building (i.e. Uniform Building Code). By examining the horizontal FRS curves of the containment structure, auxiliary building, and intake structure of ANO-1, it is observed that the corresponding frequency of the peak response of each floor does coincide with the fundamental frequency of the respective building. For the majority of the floors only one distinctive peak was depicted, and it is therefore concluded that the overall horizontal response of each building is decisively governed by the fundamental mode of the building. To derive the SSE horizontal response by extrapolation of the OBE horizontal response with the derived multiplication factor based on the fundamental frequency, is therefore justified.

In addition it should be understood that for seismic design of components by analysis, the allowable stress for the SSE load case is normally twice that allowed for the OBE. The deadweight and pressure stresses are the same in both cases. Therefore, the OBE rather than the SSE governs design as long as the SSE spectral loads are equal to or less than twice the OBE spectral loads.

NRC Comment #3:

The licensee used three components of earthquakes, combining each horizontal component with the vertical component concurrently.

ANO-1 Supporting Information #3:

Considering the following facts and observations, it can be concluded that the method of response combination used in the analysis is adequate to predict maximum structural responses:

- The typical licensing basis for plants of ANO-1's vintage permits combination of response from one horizontal and one vertical direction by square root of the sum of the squares (SRSS). However, combining responses by absolute sum would result in a more conservative value than SRSS.

- The maximum directional earthquake responses do not normally occur at the same time, therefore; combining each horizontal component with the vertical component concurrently can yield conservative results.

- With reference to Section 5.2.1.5.7.5 of the ANO-1 SAR, the torsional effects on the structural responses were found to be insignificant. No coupling effect is expected from two orthogonal horizontal input motions. Therefore, combining two horizontal and one vertical input motion by SRSS, which is only imposed in the licensing of recent power plants, would not generate appreciably different results from the SRSS of one horizontal and one vertical input motion for the FRS.

- Conservatism applied in the analysis (generation of synthetic time history, neglecting the radiational damping, etc.) are more than enough to compensate for the requirement to combine the three directional responses by the SRSS method.

NRC Comment #4:

No vertical analysis was performed; however, the licensee assumed an infinitely rigid structure in the vertical direction and took a constant value of 0.22g as the peak vertical acceleration at all elevations of the Reactor Building, Auxiliary Building, and the Intake Structure.

ANO-1 Supporting Information #4:

Vertical analysis of the structures was deemed unnecessary as the structures were judged to be rigid (f>33 Hz) in that direction. The seismic analysis results of the ANO-2 structures show that there are no significant frequencies in the vertical direction below the rigid range (see ANO-2 SAR Section 3.7.2.2 and Table 2.7-7). These results validate the assumption used for the ANO-1 structures. The constant value of 0.22g as the peak vertical acceleration (for the ANO-1 buildings and floor elevations) is also conservative based on the fact that the structures are rigid in that direction and that the design basis earthquake (DBE) horizontal ground acceleration is 0.2g.

NRC Comment #5:

The licensee has not provided any information to indicate that it considered the variation of foundation soil properties in its analysis to generate the FRS.

ANO-1 Supporting Information #5:

Variation of soil properties used for SSI is only imposed in Standard Review Plan (SRP) 3.7.2, Revision 2, effective in November 1989. In Revision 1, effective July 1981, the SRP is silent about this. However, by reviewing the generated response spectra for ANO-1 (Attachment 1 of ANO correspondence 0CAN099201, dated September 18, 1992), the response spectra curves have been smoothed at the peak response and gradually have been "fattened" at the lower portion of the curves. It can be seen that some type of widening was exercised when plotting of the curves manually (see Attachment 2). The responsible Architect-Engineer for ANO-1 indicated that the widening and smoothing were done by judgement considering that there might be variation of

soil properties and uncertainties in concrete properties. The impression was that approximately ±20 - 30 percent of the broadening was done manually. This approach was typically done by industry in the design of nuclear power plants of ANO-1's vintage.

A comparison was made between the FRS generated for ANO-1 and ANO-2 as depicted in Attachment 2 which illustrates the acceleration response spectrum of 2% damping at the top of the intake structure (Floor Elevation 378 ft. - 0 in.) of both units. As stated in the ANO-2 SAR, the FRS of ANO-2 was broadened following the criteria imposed in Bechtel Topical BCTOP-4A, "Seismic Analysis of Structures and Equipment for Nuclear Power Plants", by Bechtel Power Corporation, November 1974, which was approved by the NRC. The spectra broadening was specified "to account for the effect of structural frequency variation both due to the possible variations in the material properties of the structure and soil, and due to the uncertainties in the technique of seismic analysis." As can be seen from Attachment 2, the range of FRS broadening for both ANO-1 and ANO-2 is comparable. Therefore, it is believed that the response spectra curves generated for the OBE seismic input motion have significant implicit conservatism in them and that variation of soil properties was one of the factors considered in the widening. It should be noted from Attachment 2 that the peak response of ANO-1 is about 50% higher than that of the corresponding location of ANO-2. But this is not always the case, so no credit is taken for this.

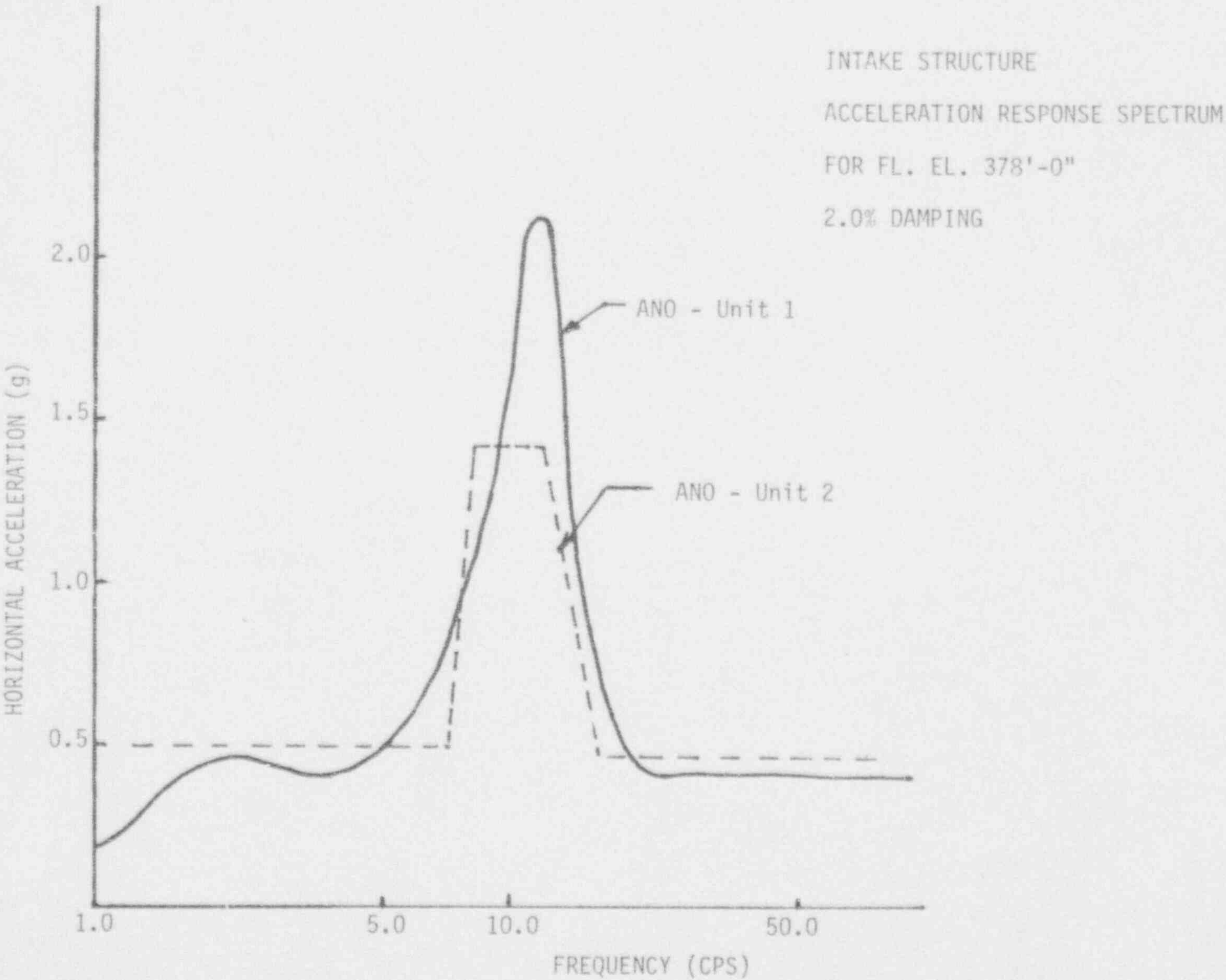
NRC Comment #6:

No peak broadening has been done in developing the FRS curves to account for modeling uncertainties.

ANO-1 Supporting Information #6:

As mentioned in response to Comment #5, floor spectra widening was performed for ANO-1 and the range of widening could even exceed today's standard practice (± 15%). Although no specific details have been specified for "peak broadening" as with current practice, the peak has been smoothed to a round shape which exhibits a good approximation to the peak broadening. It is therefore judged that the FRS as shown are adequate for use. Also, peak broadening does not have any impact on the extrapolation from the OBE FRS to obtain the SSF FRS.

The above responses are being provided by Entergy Operations at ANO-1 with consultation of our Architect-Engineer, Bechtel, and have been reviewed by Stevenson and Associates.



Attachment 2