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Admiral Kinnaird R. McKee
Deputy Assistant Director
for Naval Reactors
Department of Energy
Washington, D. C. 20585

Dear Admiral McKee:

By letter dated May 25, 1982, you requested that NRC provide comments on the seismic design basis for the SIC prototype reactor plant located at Windsor, Connecticut. We have reviewed the information submitted by DOE regarding the Windsor Site; have met with representatives from DOE, D'Appolonia and GE; and conclude that there are no geologic hazards present, such as capable faults, landslide or ground collapse, which could affect safety-related features at the site. We further conclude that, assuming that significant amplification due to soil characteristics does not occur at the plant site, the proposed Safe Shutdown Earthquake acceleration of 0.2g is reasonable for the seismic design basis at the plant site and the Operating Basis Earthquake acceleration of 0.08g is an adequate representation of the acceleration which could reasonably be expected to affect the plant site during the life of the plant. It should be noted, however, that an earthquake with a magnitude (m_b) of 5.7 and an Intensity (MM) of VI occurred in central New Brunswick, Canada on January 9, 1982 in geologic terrain that appears to be similar to that in New England. Investigations of this earthquake are underway. As these studies are still in the early stages, it would be premature to consider them in the estimation of the controlling earthquake for the Windsor site. Thus, the proposed SSE and OBE accelerations of 0.2g and 0.08g, respectively, applied as high frequency anchors of the Regulatory Guide 1.60 response spectrum, are considered adequate for the Windsor Site.

Enclosed is a review performed by our staff concerning the geology and seismology of the SIC site. A supplement to the review, which is based on information which was not available to the NRC staff at the time that the first review was prepared, is also included.

Sincerely,

Mason J. Case

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

Rej. 257

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Edson G. Case

Harold R. Denton, Director
Office of Nuclear Reactor Regulation

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Deputy Assistant Director
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REVIEW OF THE GEOLOGY AND SEISMOLOGY OF THE SIC PROTOTYPE REACTOR PLANT

Summary

We have completed our review of the geology and seismology sections (2.5.1, 2.5.2 and 2.5.3) of the report, "Basic Geologic and Seismic Information, Vibratory Ground Motion, Windsor Site" by D'Appolonia. We find the analyses to be thorough and accurate. NRC staff conclusions concerning the Montague site, which lies 50 miles to the north, and the Haddam Neck site, which is located 30 miles to the south, were also weighted heavily in this review. The findings are reported in the Safety Evaluation Reports for these two sites (US NRC, NUREG-0091, 1976, and US NRC, Systematic Evaluation Program, Haddam Neck, 1982). Other pertinent information was derived from the NRC sponsored New England Seismotectonic Study.

The local geology in the vicinity of the site is described in the D'Appolonia report. Several faults have been identified within a five-mile radius of the site. The report concludes that the faults are not capable because overlying Pleistocene deposits were not observed to be offset. Based on our assessment of similar faults and their relationship to overlying Pleistocene soils in the Montague site vicinity, in the area around the Haddam Neck site, and faults investigated as part of the New England Seismotectonic Study, we agree with the conclusion that the faults are not capable. However, this conclusion should be supported by further data and evaluations.

An earthquake with a magnitude (m_b) of 5.7 and an Intensity (MM) of VI occurred in central New Brunswick, Canada on 9 January, 1982 in geologic terrane that appears to be similar to that in New England. Investigations of this earthquake are underway. As these studies are still in the early stages it would be premature to consider them in the estimation of the controlling earthquake for the Windsor site. The proposed design bases of 0.20g for the Safe Shutdown Earthquake (SSE), and 0.08g for the Operating Basis Earthquake (OBE) anchored to the Regulatory Guide 1.60 Spectrum are considered adequate.

Geology

The site is located within the Connecticut Lowland of the New England Upland section of the New England physiographic province (Thornbury, 1965). From northern Massachusetts to Central Connecticut, the Connecticut Lowland is one of the Triassic-Jurassic basins which characterize the eastern seaboard and eastern Appalachian Mountains from the Gulf of Maine to Georgia. The Connecticut Basin is 20 miles wide and 100 miles long. The basin is a trough that has been down folded and/or down faulted in Paleozoic or older crystalline rocks which bound the basin and underlie it at depth. The trough is filled with several thousand feet at sandstones, siltstones, shales, claystones and diabase dikes, sills and flows. The uppermost rock unit under the site is the Portland arkosic sandstone of the Triassic Newark group. The rocks of the region are overlain by a few feet to more than 100 feet of Pleistocene glacial deposits. The upper 10 to 20 feet beneath the site area are sands, clays and silts deposited from glacial Lake Hitchcock.

The site is in the New England-Piedmont tectonic province (US NRC Montague, 1976 and Haddam Neck, 1982). This tectonic province is characterized by northeast-southwest anticlinoria and synclinoria. The site is within one of these major folds--the Connecticut Valley Synclinorium. There are many faults in the region, particularly in the basement rocks to the east and west of the Triassic-Jurassic Basin. The most significant regional faults are those bordering the basin. These faults are at least 138 million years old.

The site is located at an elevation of about +180 feet mean sea level just south of the Farmington River, which flows east at this location. The site is underlain by 130 feet of stratified drift and alluvium, mostly sands and gravels. Below these deposits the Mesozoic rocks strike N10°E and dip 0 to 20° east. Because of the nature of deposition of the surficial soils it is possible that loose zones are present below foundation levels. This condition is being examined by the Hydrological and Geotechnical Engineering Branch (HGEB).

Several faults have been mapped within 5 miles of the site. Figure 2.5.1-8A (Bedrock Geologic Map) shows the locations of these faults in the site vicinity which are exposed in Triassic rock outcrops in the Connecticut Basin. The faults were identified in most cases by obvious offsets in the Triassic rocks.

The Rainbow Fault is located about 2 miles north-northeast of the site. It is a reverse fault that strikes north-south and dips at a high angle (65°) with the east side up. This fault can be projected along topographic linears to 1 mile northeast of the site. The Hatchett Hill Fault strikes north-south and is down to the west. It trends to 2 miles west-northeast at the site. A northeast trending fault displaces the Hatchett Hill Fault about 4 miles northwest of the site. A fault is mapped in Triassic rock 2.5 miles northwest of the site. Displacement is down to the west. This fault can be projected along topographic linears to the site. The East Granby Fault is mapped in the Triassic rocks exposed 3 miles west-northwest of the site. Displacement is down to the west. An aeromagnetic anomaly extends perpendicularly to the Triassic rock ridges from the mapped fault to the southeast toward Bradley International Airport. An extension of the fault can also be projected along topographic linears to the Farmington River, 3/4 mile northwest of the site.

A statement is made that none of the faults discussed in the report are capable, indicating that Pleistocene glacial deposits which cover the Mesozoic sediments in the basin are not offset by the faults. Based on our reviews of the Montague site, the Haddam Neck site and mapping in the area as part of the New England Seismotectonic Program, we agree with that conclusion. However, the geologic maps, Figures 2.5.1-7 and 2.5.1-8A, raise some questions as to whether or not the surficial soils are offset.

Figure 2.5.1-7 shows distribution of glacial deposits in the site vicinity. The map is a composite of four quadrangles, each mapped by different geologists, therefore it is not surpising that some lithologic boundaries follow quadrangle borders because of different field interpretations by the individuals mapping in each area. However, along a projection of the East Granby Fault, which lies within the West Springfield Quad, there are not only topographic linears, but also different Pleistocene lithologies that appear to abutt on opposite sides of the linears or very near the linears. The same can be said about the small fault east of Marsh Pond, and sections of the Hatchett Hill Fault. It isn't likely that the Pleistocene deposits are offset by the faults based on other mapping throughout the region, where such relationships have been closely examined, but the maps suggest that they are offset. To support the conclusion that the faults are not capable, and to prevent future misinterpretation of the maps, the following additional information is requested.

a. Present the data that support your statement that the faults discussed in the report are not capable; such as locations and descriptions of exposures that were examined or mapped in the field that demonstrate the lack of offset of Pleistocene deposits.

b. Furnish any discussion in the literature regarding this subject. For example, the authors' discussion that accompanies the geologic maps, etc.

Seismology

The staff has reviewed section 2.5.2 of the Preliminary Safety Analysis Report (PSAR) for the Windsor Site and finds that the applicants proposed safe shutdown earthquake (SSE) is reasonable for the seismic design basis of nuclear reactors in this region and the operating basis earthquake (OBE) is adequate to characterize that earthquake which could reasonably be expected to affect the site during the operating life of the plant.

In its PSAR for the Windsor Site, the applicant has followed the tectonic province approach to determine the vibratory ground motion to be used for the seismic design basis. Two important aspects in this approach are the earthquakes which can be considered to be associated with known tectonic structures and the earthquakes which occur in the same tectonic province as the site or in tectonic provinces part of which are within 200 miles (320 kilometers) of the site but which cannot be reasonably associated with known tectonic structures. Where the occurrence of historic earthquakes can be correlated with tectonic structure, the ground motion at the site is estimated assuming that the largest earthquakes related to the structure could occur at the point on the structure closest to the site. Where the occurrence of the earthquake cannot be reasonably associated with a tectonic structure the ground motion at the site is usually estimated assuming that the largest historic earthquake in the tectonic province can occur near the site and that earthquakes in tectonic provinces within 200 miles (320 kilometers)

of the site can occur at the point in that tectonic province closest to the site.

The PSAR states that the Windsor site is in the New England Tectonic Province which it defines as including the New England states and New Brunswick, Canada. The highest intensity earthquakes to have occurred historically in this tectonic province which cannot be associated with known tectonic structure had maximum Modified Mercalli (MM) intensities of VII. The highest intensity earthquake to have occurred historically in a tectonic province or source zone part of which is within 200 miles (320 kilometers) of the site is the maximum MM intensity VIII Cape Ann earthquake of 1755. The closest point in the source zone (the White Mountains Structural Zone as defined in the PSAR) is approximately 100 miles (160 kilometers) from the site. Based on this, the applicant has taken the position that assuming that an intensity VII could occur near the site results in a higher intensity than the intensity which could be caused by the maximum earthquakes in other tectonic provinces and the structural zone. As an added conservatism they have considered the maximum event capable of occurring anywhere in the site province to be of MM intensity VII-VIII.

The applicant used the relationship of Trifunac and Brady (1975) to calculate the peak horizontal ground acceleration of 0.19g corresponding to a site intensity of MM VII-VIII. A value of 0.20g was used as the zero period anchor point of a Regulatory Guide 1.60 response spectrum to define the SSE. Existing nuclear power plants in this region, such as

Haddam Neck, Millstone and Pilgrim, have SSE's which are the same as or less than that proposed for the Windsor site.

In recent reviews of nuclear power plant sites it has been the staff's position that magnitude is a more suitable characterization of earthquake size than is intensity. When magnitude is used in conjunction with site geology to select earthquake time histories for use in obtaining site specific response spectra, the result is more appropriate than that obtained using peak acceleration derived from intensity data to anchor a standard spectral shape. For the eastern United States the staff equates earthquakes of maximum intensity VII with magnitude (m_b) of approximately 5.3. The Windsor site would be considered a soil site since it is underlain to a depth of over 100 feet by glacial deposits. The PSAR characterizes the shear wave velocities at the site as a function of depth. From the surface to a depth of 45 feet the average shear wave velocity is about 680 feet per second. The average shear wave velocity is 1500 feet per second from depths of 45 feet to 100 feet. At depths between 100 and 150 feet the shear wave velocity increases from 1500 to 6,100 feet per second. A comparison of the proposed site SSE (0.20g Regulatory Guide 1.60) response spectrum with the 84th percentile level of several spectra developed for magnitude 5.3 earthquakes recorded at soil sites shows that the Windsor SSE spectrum exceeds the others in the frequency range of interest for nuclear power plants. The soil response spectra which were compared with the proposed SSE spectrum were not developed for sites with the exact soil conditions as those at the Windsor site. The thickness of

the layers and the velocity contrasts between layers determines the frequencies at which amplification may occur and the amount of possible amplification. However, in general the result of the comparison was conservative and it is the staff's position that the proposed SSE is reasonable for the seismic design basis at the site.

In January 1982 there was an earthquake in central New Brunswick, Canada which had a magnitude (m_b) of 5.7 and intensity VI. There is not much known about the geology of that region so it is not now possible to associate this earthquake with a particular tec onic structure. We are presently evaluating this earthquake with respect to tectonic province and possible correlation with local structure. However, we can assess the conservatism of the 0.20g design with respect to the possible occurrence of this earthquake near the site based on some comparisons. The 0.20g Regulatory Guide SSE spectrum is roughly equivalent to the 84th percentile level of spectra developed from magnitude 5.8 earthquake recorded at soil sites at periods less than 0.4 seconds and generally exceeds the 84th percentile level of the soil spectra at periods greater than 0.4 seconds. Here also, the soil spectra were not obtained for sites with the same layer thickness and velocity contrasts as those at the Windsor site and there might be some characteristics at the Windsor sites which are different than those at the other sites. The evaluation of the New Brunswick earthquake is still in its early stages and it would be premature to consider it in the estimation of the controlling earthquake for the Windsor site.

The applicant has proposed an operating basis earthquake (OBE) characterized by a peak horizontal acceleration of 0.08g as a high frequency anchor of a Regulatory Guide 1.60 spectrum. To justify this characterization the applicant has performed a probabilistic study and estimates a return period for this event of approximately 900 years. Based on the definition of the OBE as being that earthquake which could reasonably be expected to affect the plant site during the operating life of the plant it appears that the proposed OBE is adequate.

Conclusion

The staff concludes that the proposed SSE of 0.20g and OBE of 0.08g applied as high frequency anchors of Reg. Guide 1.60 spectrum are adequate. We further conclude, based on our studies of other sites in the region, that there are no capable faults in the site vicinity, however, we require additional documentation to confirm that finding.

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1. Barosh, P.J. and P. V. Smith, 1981, New England Seismotectonic Study Activities During Fiscal Year 1980; prepared for the U. S. Nuclear Regulatory Commission.
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3. Thornbury, W.D. 1965, Regional Geomorphology of the United States; John Wiley and Sons, New York.
4. Trifunac, M.D. and A. G. Brady, 1975, On the Correlation of Seismic Intensity Scales with the Peaks of Recorded Strong Motion; Bulletin of Seismological Society of America, Vol. 65, pp. 139-162.
5. U. S. Atomic Energy Commission, 1973, Design Response Spectra for Seismic Design of Nuclear Power Plants; Regulatory Guide 1.60.
6. U. S. Nuclear Regulatory Commission, 1976, Safety Evaluation Report, Montague, Units 1 and 2; NUREG 0091.
7. U. S. Nuclear Regulatory Commission, 198?, SEP-Haddam Neck Nuclear Station, Topics II-4-Geology and Seismology, and II-4B-Capability of Faults in the Site Region; 18 May, 1982 memorandum for G. C. Lainas from J. P. Knight.

REVIEW OF THE GEOLOGY AND SEISMOLOGY OF THE SIC PROTOTYPE REACTOR PLANT - SUPPLEMENT 1

The geology and seismology of the SIC Prototype Reactor Plant was described in the D'Appolonia report, "Basic Geologic and Seismic Information-Vibratory Ground Motion". Geosciences Branch reviewed that report and presented its findings in an SER transmitted by letter from R. E. Jackson to B. J. Youngblood on 20 August, 1982. Several faults had been mapped in the Triassic rocks in the site vicinity and were described in the report. The staff concluded, based on its evaluation of similar faults near the Montague site to the north and the Haddam Neck site to the south, that the faults were not capable. However, surficial geologic maps provided in the PSAR suggested that glacial deposits along projections of some of the faults may be offset, and it was not clear to what extent these faults had been examined to find positive evidence that overlying soils were or were not displaced.

Although it was very unlikely that the faults were capable the staff requested the following additional information:

1. presentation of the data that support the statement in the PSAR that the faults discussed are not capable; such as locations and descriptions of exposures that were examined or mapped in the field that demonstrate lack of offset of Pleistocene soils; and

2. submittal of any discussion in the literature that had a bearing on the age of the faults.

D'Appolonia responded by describing fault outcrops visited, and where possible, the relationships of these faults to surficial soils. Only one fault outcrop showed a clear relationship between the fault and undisturbed overlying Pleistocene deposits. The following findings are presented to support the conclusion that the faults are not capable according to Appendix A 10 CFR Part 100.

1. The Rainbow fault, which is the closest mapped fault to the Windsor site, is capped by unfaulted glacial soils of Pleistocere age.

2. Pleistocene soils in the vicinity of the faults do not contain any fault material (angular and relatively fresh broken particles) as would likely be the case if the faults underwent displacement in the Pleistocene.

3. There is no correlation between historic earthquake epicenters and mapped faults, and

4. The nature of the mapped faults appears to be consonant with pre-Quaternary (Mesozoic) tectonics.

Based on this information and our assessment of similar faults mapped during the Montague review and faults mapped as part of the NRC-sponsored New England Seismotectonic study, we conclude that the faults in the vicinity of the Windsor site are not capable according to the criteria set forth in Appendix A.