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Report to AEC Regulatory Staff

ADEQUACY OF THE STRUCTURAL CRITERIA FOR THREE MILE ISLAND NUCLEAR STATION UNIT I

Metropolitan Edison Company

(Docket 50-289)

by

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and
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INTRODUCTION

This report is concerned with the adequacy of the containment structures and components for Three Mile Island Nuclear Station Unit 1 for which application for a construction permit has been made to the U. S. Atomic Energy Commission by the Metropolitan Edison Company. The facility is located on Three Mile Island near the east shore of the Susquehanna River in Dauphin County, Pennsylvania.

Specifically this report is concerned with the design criteria that determine the ability of the containment system, piping, and other critical components to withstand a design earthquake of 0.06g maximum transient horizontal ground acceleration simultaneously with the other applicable loads forming the basis of the design. The facility also is to be designed to withstand a maximum earthquake of 0.12g horizontal ground acceleration to the extent of insuring safe shutdown.

This report is based on information and criteria set forth in the Preliminary Safety Analysis Reports (PSAR) and the supplements thereto as listed at the end of this report. Also, we have participated in discussions with the AEC regulatory staff concerning the design of this unit.

DESCRIPTION OF FACILITY

Three Mile Island Unit 1 is described in the PSAR as being a complete nuclear power unit, licensed for operation at power levels of 2452 MWt (845 MWe). The nuclear steam supply system is to consist of a pressurized water reactor to be supplied by the Babcock and Wilcox Company, quite similar

to other units now under construction such as Oconee Nuclear Station Units 1 and 2, Turkey Point Units No. 3 and 4, and Indian Point Unit No. 2.

The containment building, consisting of a prestressed, post-tension concrete reactor building, is similar in design to that employed for Turkey Point, Palisades and Point Beach. The containment building has an inside diameter of about 130 feet, is about 187 feet high, with a cylindrical wall thickness of $3\frac{1}{2}$ feet, and the dome thickness is $3\frac{1}{2}$ feet. The foundation mat will be approximately 9-foot thick with a 2-foot thick concrete slab above the bottom liner plate. The liner plate thickness will be 3/8 inches for the cylinder and dome and 1/4 inch for the base. Unlike most other designs of this type, within the containment building the two steam generators are enclosed in semicircular containment barriers; i.e. there is a rather substantial concrete wall between the steam generator and the wall of the containment building.

The geology report indicates that the bed rock surface at the site is essentially flat and consists of Gettysburg shale. The bed rock at the site is overlain by a fluvial sand and gravel of about 20 ft. thickness containing varying amounts of silt, clay, and occasional lenses of clear sand. In the vicinity of the proposed plant site the depth of soil over bedrock is about 20 feet. Section 2.1 of the PSAR indicates that the containment structure will be founded on the bedrock. However, in examining the elevations in Section 1 of the PSAR it appears that not all structures will be founded on the shale but many of them will be founded at grade and at other elevations. It was reported that there is no evidence of faulting at the site.

SOURCES OF STRESSES IN CONTAINMENT STRUCTURE AND TYPE I COMPONENTS

The reactor containment building is to be designed for the following loads: deadload; liveload; an internal pressure of 55 psi; a test

pressure of 63.3 psi; an external atmospheric pressure 2.5 psi greater than that of the internal pressure; an external vacuum of 3 psig; a tangential wind velocity of 300 mph corresponding to a tornado; normal wind loading corresponding to 100 year frequency wind as determined from ASCE Paper No. 3269 (Wind Forces on Structures); an internal temperature under operating conditions of 110°F; an accident temperature of 281°F; and prestressing loads. In addition, Section 5.1.2.3.4 indicates that the building design will take into account any buoyancy that may arise from flood conditions.

The reactor containment building will be designed for a maximum horizontal component of ground acceleration of 0.06g and for a maximum ground acceleration of 0.12g for no loss of function.

The discussion on page 5A-1 indicates that the critical Class I piping and internals will be designed for the same earthquake loadings just noted. A similar statement for the internals is given on page 3-53 of the PSAR. However, in the case of the piping and internals we do not have an indication of how the loads will be combined, as will be discussed later.

Class II components are to be designed for a maximum ground acceleration of 0.06g in accordance with the Uniform Building Code procedures.

COMMENTS ON ADEQUACY OF DESIGN

Seismic Design Criteria -- We agree with the approach involving a basic design for a design earthquake of 0.06g horizontal ground acceleration with the provision that safe shutdown can be achieved for a maximum earthquake of 0.12g. These earthquake design values are in agreement with those given by the U. S. Coast and Geodetic Survey (Ref. 3).

The vertical acceleration is noted to be taken as 2/3 of the horizontal component, and we concur with this approach.

The response spectra for the design earthquake were originally presented in Figures 1 and 2 of Appendix 2B of the PSAR, and corresponded to the 1957 Golden Gate earthquake. Subsequently, the applicant notes in answer to Question 3.1 of Supplement 1 that the revised acceleration response spectra (as presented in Figure 3.1-1) reflect the greater response at lower frequencies based upon the 1940 El Centro spectra. We have verified that the spectrum shown in Figure 3.1-1 corresponds roughly to the envelope of the spectra corresponding to the 1957 Golden Gate spectra and the 1940 El Centro spectra. It is difficult to interpret and check such spectra when plotted to an arithmetic scale. On the assumption that the envelope as noted, and not the individual earthquakes separately, will be employed in the design, we concur in the spectra as amended.

The method of analysis for handling the dynamic excitation is described on page 5A-3 with revisions as described in Appendix 5C. The design approach noted there appears acceptable to us. However, further comment is given in answer to Question 3.1 wherein it is noted "for other than a modal analysis the mathematical models will be subjected to the ground motion described as acceleration as a function of time. The input ground motion shall individually be the 1957 Golden Gate Park, San Francisco earthquake, and the 1940 El Centro earthquake, both normalized to 0.06g for the design earthquake and 0.12g for the maximum probable earthquake. The design will satisfy both accelograms". The design approach involving a time history of ground motion is acceptable to us only if the combined motions of the two separate earthquakes are considered, or as long as the design corresponds to the envelope of the two spectra noted. for any given value of damping.

The damping values to be employed in the design are listed on page 5A-3 of the PSAR. It is noted in answer to question 3.2 of Supplement 1 that the damping values will be applied to the maximum earthquake as well as to the design earthquake. The damping values given are acceptable to us with the restriction that, should any concrete structures above ground be employed with a 5 percent damping value as noted, the cracking associated with this high damping value must be taken into account if it involves any equipment or other items associated with safe shutdown. It is noted that the damping for the reactor building is 2 percent which is acceptable to us.

The statement on page 5A-2 of the PSAR indicates that the primary steady state stresses, when combined with the seismic stress and occurring simultaneously, shall be limited so that the function of the component system of structures will not be impaired in a manner that might prevent a safe and orderly shutdown. This statement indicates that the seismic stresses will be combined with the primary stresses. A further elaboration of this point is given in answer to Question 7.2-1 where it is noted that the vertical and horizontal frequencies will be added. This latter statement is unacceptable for the matter here is one of adding appropriate stresses, not frequencies, arising from the seismic loadings with the stresses arising from deadload-liveload, etc. which occur at a particular point. These stresses are to be added directly and linearly in all cases. This matter requires further clarification on the part of the applicant.

With regard to the design of the reactor containment building, the combination of loadings and load factors presented on page 5B-2 (revised 10-2-67) are acceptable to us.

The matter of combination of loadings involving the dead load, pressure, and temperature loading arising from accident, and earthquake

loading receives further attention in answer to Question 3.3-1 of Supplement 1. The answer that is given there is not clear insofar as compounding of loadings is concerned for the design of components other than the reactor building. One can infer generally from the discussion of pages 5A-3 and 5A-4 that all applicable loadings will be combined, but the statements are not clear. It is our recommendation that applicable loading combinations be applied for piping, reactor internals and other Class I equipment in the same manner as for the reactor containment building, and that clarification of the statement given in answer to Question 3.3 must be provided by the applicant.

A discussion of the design of reactor building cranes is presented in answer to Question 3.2 of Supplement 1. The design criteria are still not clear even with reference to Appendix 5A, for in addition to stress design, the problem with cranes is to insure that they cannot be displaced from the track and in doing so damage equipment which would be required for safe shutdown. Further clarification on the crane design problem is necessary.

With regard to the overall design of the reactor containment building, it is noted on page 5B-2 of the PSAR that the load deformation behavior of the structure is one of elastic low-strain response. Furthermore, it is noted that the strain in the steel liner plate will not exceed one-half percent strain. These criteria are acceptable to us.

The design of the penetration is discussed on page 5B-5 of the PSAR and further elaboration is given in answer to Question 7.3 of Supplement 1. It is noted therein that a finite element solution will be employed for the design and further that the equipment and personnel accesses will be reinforced to withstand computed stress concentrations and to insure approximate strain compatibility within the shell. This approach is acceptable to us.

The PSAR indicates that the containment building will be founded on bedrock. Many of the other buildings appear to be founded on soil at grade and this assumption is reinforced by the discussion given on page 3.2-2 of Supplement 1 wherein there is a discussion of relative motions between the various buildings. The discussion there indicates that the allowable stress values corresponding to the relative motions will be based on code values and held lower than normal. The exact meaning of this is not clear and it would be desirable to have some indication of the amounts of ductility that would be provided rather than the stress limits, for this is primarily a deformation problem.

We find little discussion of the manner of carrying the shear arising from earthquake loadings in the structural reactor containment building. Some comment is given on this matter on page 5C-4 of the PSAR. It would be our recommendation that net principal tension not be permitted on a section which is required to carry shear; however, we are willing to permit a net principal tensile stress of $3\sqrt{f'_c}$ excluding bending or flexural stress and $6\sqrt{f'_c}$ when local bending arising from thermal loads is included.

The answer to question 7.10 of Supplement 1 and Appendix 5D of the PSAR indicates that Cadweld splices will be employed for all bars of sizes larger than no. 11. We are in agreement with this approach.

Corrosion Protection -- Section 5.1.2.a of the PSAR indicates that corrosion protection will be provided to protect the liner plate, the tendon steel casings, and all reinforcing bars below grade. We are in agreement with this approach.

Long Term Surveillance is discussed in answer to Question 8.7 of Supplement 1. It is indicated there that there will be little need for long term surveillance other than that of monitoring cracks and dimensional

changes of the structure. We concur in this latter approach but believe that it would be desirable to provide for periodic tendon inspection at the anchorages in addition to a systematic monitoring of structural dimensional changes, crack surveillance program, etc.

Piping and Internals -- Some comments on the piping design is contained in answer to Question 3.2 of Supplement 1. The discussion there indicates that for the design earthquake the stresses will be held within allowable working stress limits as set forth in the Power Piping Code. For the no-loss-of-function earthquake the stresses are to be limited so that they do not exceed the material yield stress and so that the function of the connected component system will not be impaired and that a safe orderly shutdown of the plant can be made. This approach appears acceptable to us as long as the design includes a combination of all the applicable loads as noted earlier in our report, a point which remains to be clarified by the applicant. There is no specific comment in this connection with regard to the reactor internals and this needs to be provided by the applicant.

Intake Structure and Emergency Water for Shutdown Cooling -- A discussion of this problem occurs in answer to Question 2.2 of Supplement 1 and it appears that normal stream channel flow will be sufficient for handling shutdown in the event of failure of the New Haven Dam. It is indicated there that the intake structure will be constructed at an elevation to take water from the bottom of the river and to maintain minimal submergence from the intake pumps at all times. No mention is made of the problem of ice if this can occur at the site but it is assumed that provisions will be made for handling ice loadings.

CONCLUSIONS

On the basis of the information presented, and in keeping with the

design goal of providing serviceable structures and components with a reserve of strength and ductility, we believe the design criteria outlined for the containment system and other Type I structures and equipments can provide an adequate margin of safety for seismic resistance if the topics listed below are resolved. In reaching this conclusion we assume that the applicant will give further consideration to the matters of compounding the horizontal and vertical earthquake stresses with other applicable stresses, loading criteria in terms of combinations of loads required for piping and internals, stability of cranes, relative motions between the buildings and the piping connections thereto, the stress criteria for shear, the design criteria for piping and internals, and ice loadings.

REFERENCES

1. "Preliminary Safety Analysis Report -- Volumes 1, 2, and 3," Three Mile Island Nuclear Station Unit 1, Metropolitan Edison Company, 1967.

2. "Preliminary Safety Analysis Report -- Volume 4 (Suppl. No. 1)," Three Mile Island Nuclear Station Unit 1, Metropolitan Edison Company, 1967.

3. "Report on the Seismicity of the Three Mile Island Nuclear Station Unit 1," U. S. Coast and Geodetic Survey, Rockville, Maryland, ____.