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REPORT TO AEC REGULATORY STAFF

ADEQUACY OF THE STRUCTURAL CRITERIA

for

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
(AEC Docket No. 50-247)

by

N. M. Newmark and W. J. Hall

Urbana, Illinois

10 August 1966

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ADEQUACY OF THE STRUCTURAL CRITERIA

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INTRODUCTION

This report is concerned with the adequacy of the containment structures and components for the 275[0] MWt Indian Point Nuclear Generating Unit No. 2, hereafter referred to as Indian Point Unit 2, for which application for a construction permit and operating license has been made to the United States Atomic Energy Commission by the Consolidated Edison Company of New York, Inc. The facility is located on the east bank of the Hudson River at Indian Point, village of Buchanan, in upper Westchester County, New York. The site is about 24 miles north of the New York City boundary, and 2.5 miles southwest of Peekskill, New York. Indian Point Unit No. 2 will be built adjacent to Unit No. 1.

The reactor system consists of a pressurized water reactor and steam generator which will be employed to produce steam for use in a steam-driven turbine generator.

Specifically, this report is concerned with the evaluation of the design criteria that determine the ability of the containment system to withstand a design earthquake of 0.1g horizontal and 0.05g vertical transient ground acceleration simultaneously with the other loads forming the basis of the containment design. The facility also is to be designed to withstand a maximum earthquake loading of 0.15g horizontally and 0.1g vertically to the extent of preserving the ability to maintain the plant in a safe shut-down condition.

This report is based on information and criteria set forth in the preliminary safety analysis reports (PSAR), and supplements thereto as listed at the end of this report. We have participated in discussions with the applicant and its representatives, as well as the AEC Regulatory Staff, concerning the design of this unit. As will be noted in the three supplements and the memorandum (Ref. 7), a number of questions have been raised about the design of the containment and further comments on the questions, answers and criteria cited are contained herein.

DESCRIPTION OF THE CONTAINMENT FACILITY

The reactor containment consists of a reinforced concrete shell in the form of a vertical right cylinder with a hemispherical dome and a generally flat base supported on rock. The cylinder is 135 ft. in inside diameter with a wall thickness of 4 ft.-6 in.; the spring line of the dome begins at an elevation of 147 ft. above the inside surface of the base of the containment structure, has a radius of 67 ft.-6 in. and a thickness of 3 ft.-6 in. The change in wall thickness of the dome and cylinder at the spring line is to be accomplished in such a manner that the inside radius of the dome and cylinder will be equal.

The inside surface of the structural concrete is lined with steel plate anchored to the concrete shell with studs. The bottom horizontal liner plate will be covered with 2 ft. of concrete, the top of which will form the floor of the containment.

Figure 1 of Ref. 4 shows the containment base as sitting on concrete fill in one region, with unequal backfill acting on one side of the cylindrical containment shell.

COMMENTS ON ADEQUACY OF DESIGN

Earthquake Hazard and Design Procedures

The earthquake motions considered are stated in Ref. 5 as follows:

In reply to Question 9-c, "the plant design will consider the simultaneous action of horizontal and vertical earthquake accelerations. The design earthquake accelerations at zero period are 0.1g horizontally and 0.05g vertically."

In reply to Question 9-d, the statement is made that: "The Indian Point Unit No. 2 containment will satisfy this relation for seismic loads at least equal to those corresponding to the response to 0.15g horizontal and 0.10g vertical ground accelerations occurring simultaneously."

We believe that the foregoing criteria covering the earthquake motions are reasonable and satisfactory.

The response spectra to be used in the analysis are given in Ref. 5, Figs. 9-1 and 9-2, but a plot of spectra are not given for the maximum earthquake. We have considered that the response spectra to be used for the maximum earthquake are proportional to those used for the design earthquake. The applicant has stated that the combined effects due to vertical and horizontal earthquake motions will be assumed to act simultaneously in the design.

The damping values, as revised, are given in Ref. 5 in the answer to question 9-a. We consider that these damping factors are acceptable, as stated in this reference. Criteria for "no loss of function" are stated in reply to question 6 of Ref. 6, and appear adequate. A ductility factor of two (2) is to be used in the design of all Class I vessels and piping.

The applicant advises (Ref. 7) that any Class I equipment located in a Class II building, or supported by a Class II structure, will be protected from

damage during an earthquake, or will be backed up with Class I equipment, capable of providing for a safe reactor shut down, located in or attached to Class I structures. We concur in this approach.

Penetrations

The applicant describes the method of analysis of penetrations in the answer to question 2 of Ref. 6. The method is essentially an empirical one and may be adequate. An indication of assurance of adequacy can be obtained in one of several ways: for example, by theoretical analysis using a lumped parameter or finite element representation; by photoelastic analysis; by model tests; or by adequate measurements made during proof-pressure tests of the completed structure. The applicant has indicated in Ref. 7 that assurance of adequacy of the large penetrations will be provided through measurements and observations made at the time of the containment proof test. Such measurements will include (a) strain measurements to be made in the area of the stiffening ring and in areas adjacent to the opening, (b) visual inspection for cracking and (c) measurements of gross dimensional changes. We believe that acceptable results from such measurements will assure the adequacy of this aspect of the design.

Steel Liner

The design of the liner and the attachment to the concrete pressure vessel is discussed in the answer to question No. 1 of Ref. 6. We consider that a plate thickness of 3/8 of an inch, as indicated in Ref. 6, can have adequate resistance to fatigue or repeated stresses if the welding procedures are carefully controlled. Hence, an inspection procedure is essential in

which all of the stud connections to the plate and liner welds are examined. The applicant advises that 100 percent of all liner stud welds will be visually inspected, and that all liner seam welds will be pressure tested.

Concrete Reinforcement

The principal reinforcement in the dome and cylindrical shell containment vessel is listed in Ref. 4 as being "high strength billet steel conforming to ASTM A-432 with a guaranteed minimum yield strength of 60,000 psi and ultimate minimum strength of 90,000." Since this steel has a lower ductility than the lower strength steel commonly employed, adequate inspection and control procedures are essential to insure that the steel meets the requirements of the specifications; an acceptable arrangement for such procedures is given in item 5 of Ref. 7. It is noted there that special procedures will be followed to insure the adequacy of bent bars.

Concrete Shear Values

A discussion of the shearing strength of concrete under various conditions of combined loading is contained in the answers to questions 7 and 8 of Ref. 6. The applicant confirms (Ref. 7) that these latter statements mean that diagonal reinforcement will be provided to carry the entire seismic shear without participation of the liner or the concrete, except for the upper area of the dome. Also the applicant confirms (Ref. 7) that shear will not be considered to be carried by diagonal bars when they are loaded in compression. In our view, this interpretation gives an adequate capacity for shearing resistance of the containment under transverse loading.

Backfill

The structure is subjected to dead load pressures and to increased lateral forces in the transverse direction arising from the action of the

crushed-rock backfill against the structure. Since this backfill is not at the same elevation around the entire structure, the lateral force distribution on the structure arising from both dead load and seismic loading are not uniformly distributed circumferentially. Although the answer to question 5 of Ref. 6 discusses this problem, the discussion appears to be limited to the state of stress in the soil. The applicant has confirmed (Ref. 7) that he will take account of these increased lateral forces due to seismic behavior in proportioning the concrete and steel in the containment vessel.

Earthquake Effects on Crane

The stability of the crane under seismic motions is discussed in the reply to question 4 of Ref. 6. The statement is made that "the seismic design also precludes tipping of the crane and the reaction of seismic loads." Hence, the factors to be considered involve forces imposed on the crane structure from swinging loads, or the impact of such swinging loads on other parts of the structure. It is apparent from the discussion that the applicant has considered this matter. We interpret his statements to indicate that the capability of the reactor for safe shut down will not be impaired by earthquake motions that might be transmitted to the crane or through the crane to other elements.

CONCLUSIONS

On the basis of discussions at several meetings on this topic, and a recent conference call (Ref. 7) we believe that the principal structures and components designed for containment, and the other essential parts of the facility, will provide an adequate margin of safety for seismic motions.

REFERENCES

1. "Preliminary Safety Analysis Report--Description of Site and Environment," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B, Vol. I, 1966.

2. "Preliminary Safety Analysis Report--Plant Design Description and Safety Analysis," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B, Vol. II, Part A, 1966.

3. "Preliminary Safety Analysis Report--Plant Design Description and Safety Analysis," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B, Vol. II, Part B, 1966.

4. "First Supplement to: Preliminary Safety Analysis Report," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B-1, 1966.

5. "Second Supplement to: Preliminary Safety Analysis Report," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B-2, 1966.

6. "Third Supplement to: Preliminary Safety Analysis Report," Consolidated Edison Company of New York, Inc., Indian Point Nuclear Generating Unit No. 2, USAEC Docket No. 50-247, Exhibit B-3, 1966.

7. Memorandum: "Conference Telephone Conversation (of 1 August 1966) on Seismic Design of Indian Point No. II," prepared by K. Woodard, AEC, dated 4 August 1966.

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Second Draft of Report on Indian Point Nuclear Generating Unit No. 2

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