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REPORT TO AEC REGULATORY STAFF

ADEQUACY OF STRUCTURAL CRITERIA FOR WILLIAM H. ZIMMER NUCLEAR POWER STATION CINCINNATI GAS AND ELECTRIC COMPANY, ET AL.

AEC Docket No. 50-358

by

N. M. Newmark

W. J. Hall

and

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7 September 1971

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INTRODUCTION

This report concerns the adequacy of the containment structures and components of the William H. Zimmer Nuclear Power Station for which application for a construction permit has been made to the U.S. Atomic Energy Commission by the Cincinnati Gas and Electric Company, Columbus and Southern Ohio Electric Company, and the Dayton Power and Light Company. The facility is located 24 miles southeast of Cincinnati, Ohio on the Ohio side of the Ohio River, and approximately 1/2 mile north of Moscow, Ohio. This report is based on the information and criteria presented in the Preliminary Safety Analysis Report (PSAR) and Amendments thereto as referenced herein. Additional information has been obtained through discussions with the AEC Regulatory Staff.

DESCRIPTION OF FACILITY

The William H. Zimmer Nuclear Power Station is described in the PSAR as a single-cycle, forced-circulation, boiling water reactor producing steam for direct use in the steam turbine-generator unit designed for a net electrical power output of about 807 MWe.

The primary containment, which houses the reactor vessel and other components, consists of a steel-lined prestressed concrete pressure suppression system of the over-and-under configuration. The drywell, in the form of a cone, is located directly above the suppression chamber. The suppression chamber, which is cylindrical, is separated from the drywell by a reinforced concrete slab which functions as the drywell floor. In the event of an accident, the drywell atmosphere is vented into the suppression chamber through a series of downcomer pipes penetrating the drywell floor. The drywell has a base diameter of approximately 80 ft. and a top diameter of about 30 ft.

The reactor building, which comprises the secondary containment, will consist of poured-in-place reinforced concrete for the substructures and exterior walls of the building up to the refueling floor, and above this level the building structure will be steel-framed with insulated metal siding. The siding will have sealed joints, and entrance to the building will be through interlocked double doors.

LOADINGS AND SOURCES OF STRESSES

The reactor containment structures will be designed for the following loadings and conditions: dead loads; live loads; design temperatures and pressures for the drywell and suppression chamber of +45 psig internal pressure and +2 psig external pressure, and temperatures of 290°F and 275°F for the drywell and pressure suppression chambers, respectively; test pressures of 52 psig for the drywell and pressure suppression chambers; a maximum differential pressure of 25 psi applied to the drywell side for the floor separating the drywell from the suppression chamber; a wind pressure ranging from 35 to 53 psf; and a tornado loading associated with a 300 mph horizontal peripheral tangential velocity with a translational velocity of 60 mph, and an internal pressure drop of 3 psi, with associated missiles.

In addition, the design is to be made for a Design Basis Earthquake corresponding to a maximum horizontal ground acceleration of 0.20g (as noted in Amendment 5) and for an Operating Basis Earthquake corresponding to a maximum horizontal ground acceleration of 0.10g. The vertical acceleration is to be taken as 2/3 of the horizontal value.

ADEQUACY OF DESIGN

Foundations

Bedrock formations in the site area consist of limestone and shale, and are encountered at depths ranging from 83 to 88 ft. in the plant construction area. Immediately above the bedrock for a depth of roughly 60 ft., the soil consists of medium dense fine to medium and fine to coarse sand with varying amounts of silt and gravel, and occasional gravelly layers. The next 20 to 30 ft. above that is characterized by dense to medium dense and stiff interlayered silty fine sand, fine sand and clay, silt and fine sand. The top layer, up to 12 ft. in thickness, consists of very stiff clay and fine sandy silt with roots. The upper 30 to 35 ft. of soil is noted to be recent alluvial deposits and the underlying sands are believed to be of glaciofluvial origin of Pleistocene age. The nearest known fault is the Maysville Fault located about 30 miles southeast of the facility.

On page 2.5-81 (Amendment 11), it is indicated that major plant structures will be supported on mat foundations; the foundation elevations are given in Table 2.5-16. Foundation preparation will consist of densification of soils between foundation level and Elevation 450 by dewatering, excavating and recompacting existing soils. Also, as reported on page 2.5-87, soft, loose or disturbed materials at the base of the excavation will be removed.

The applicant advises in Amendment 18 that a clay blanket will be installed on all slopes of the compacted fill upon which the Class I structures are founded, and a thin layer of clay will be placed under this compacted fill foundation. Further, after completion of the foundation and base structure, observations will be made of piezometric levels inside and outside of the structural fill zone, i.e., on either side of the clay blanket, and the rate of change of water levels under partial flood conditions will be studied to determine whether pumping under the foundations of the major facility structures will be needed later. Provisions are to be made in the design so that if pumps are needed they can be installed.

With the aforementioned technique of construction, and indication by the applicant on page 12.2-13 that the foundation zone will be designed to resist a horizontal acceleration of 0.20g, we believe the possibility of any difficulties with liquefaction which could affect major plant structure is remote. We believe the general method described for construction of the foundations to be adequate.

As noted on page 12.2-13, the service water pipe located between the river intake structure and the main building complex will be supported on a pile foundation. The description provided on page 12.2-13, in Appendix J, and Amendment 18, indicates that the pile foundation will resist all downward, uplift and lateral loads for all conditions of static and dynamic loadings. The design will be made to provide for resistance against lateral forces in both the downhill and transverse directions; the forces for which the design is to be made are on the order of 360 kips per bent downhill and approximately 100 kips in the transverse direction. We believe the proposed design scheme for the service water piping to be adequate.

Figure 12.5-8 (Revised), as presented in Amendment 18, provides details of the service water pump house and intake structure design. Earth pressures at rest and dynamic pressures are to be used in design of the bulkhead, and we are advised that the design of the surrounding bank area will be reviewed to insure that the stability of the area is maintained during the normal rise and fall of the river. We believe the design of the service water pump house and intake structure is satisfactory.

Seismic Design

The earthquake design criteria and earthquake hazard were discussed in meetings with the AEC/DRS/DRL staff and representatives of NOS and USGS. As noted on page 12.2-13 (Amendment 12), the hazard for which the plant is designed is a Design Basis Earthquake characterized by a maximum horizontal ground acceleration of 0.20g and an Operating Basis Earthquake of 0.10g. We concur in the design values selected. The response spectra for the OBE and DBE are presented in Figs. 2.5-22 and 2.5-23 (Amendment 13) and we concur in use of the spectra presented.

Moduli and soil damping values for the foundation materials are presented in Table 2.5-14. No specific values are given for the compacted soils which will be employed under the facility structures. In Amendment 18, the applicant confirms that a value not greater than 7 percent be taken for the soil damping values, except for retaining walls where a slightly larger value may be used. We concur in this approach.

The methods of seismic analysis to be employed are described generally in Section 12.3 of the PSAR. This section, and answers to many of the questions in Section 12, refer to Appendix I. The analytical procedures outlined, and the damping values given for structural elements, are acceptable to us.

It is noted on page 1.1-1 that "separate reports will be developed for each major Class I structure on which a dynamic analysis must be performed. These reports will cover the specific details of each analysis and will be completed by the time the FSAR is prepared". We interpret this to mean that detailed descriptions of the methods of analysis actually employed and the significant aspects of the design, including tabulations of critical stresses and deformations, will be provided for FSAR review. We concur in this approach.

It is indicated on page 12.3-1 that the stresses resulting from the horizontal excitation will be combined linearly with those resulting from the vertical excitation. We agree with this approach.

Load and Stress Criteria

The controlling load combinations and allowable stresses for the structural elements are summarized in Table 12.2-2 and on the basis of the information presented, it appears that all structural elements will be designed to behave elastically (i.e., not exceed yield) for the maximum loading conditions considered. On this basis we concur in the criteria adopted.

Piping, Pressure Vessels, Heat Exchanges, and Equipment

The seismic design criteria for piping, pressure vessels, heat exchanges, and equipment are described in Appendix A, Appendix C, Appendix D, and Appendix I.

The method of dynamic analysis for piping and equipment supplied by the General Electric Company is described in detail in Appendix D (Amendment 4) on page D.6-1 (et seq.). The allowable stresses for this particular piping correspond to code allowable stresses. The approaches described for the recirculation piping and primary steam piping are satisfactory.

For equipment, it is indicated on page D.6-1 that for the Design Basis Earthquake the horizontal coefficient will be taken as 1.5g and the vertical coefficient as 0.14g. The applicant advises in Amendment 18 that the adequacy of the equipment to meet the specified floor response spectra will be checked in all cases and appropriate design modifications made if required. We concur in this approach.

It is our understanding that all other piping and equipment will be designed in accordance with the criteria presented in Appendix I and we are in agreement with the approach described there. With respect to allowable stresses, on pages A.3-2 and A.3-3, for Group B piping, it is indicated that piping is to remain functional either by keeping the sum of the longitudinal stresses less than the maximum specified yield stress, or by allowing stresses above yield, provided a plastic analysis shows no loss of function. The details of the manner in which the latter stress criterion will be employed, and the limitations on deformation, strain limits, or deflections are not presented. Should any of the piping be designed to stresses above yield, it is our recommendation that the specific location of such overstressing, as well as description of the pipe runs, be carefully delineated and that the stress analysis in such cases be reviewed as a follow-on item. We are advised that the applicant will confirm in Amendment 19 that plastic analyses will not be employed unless supporting data are submitted for evaluation by the AEC staff. We concur in this approach.

The applicant advises (to be documented in a later Amendment) that in developing floor response spectra a synthetic time-history base input will be employed; and, the spectra corresponding to this time history will envelope the site design basis spectra. We concur in this approach.

The seismic design of the reactor internals is described in paragraph 3.3.5.5 of the PSAR and in the answer to Question 12.3.1-1 (Amendment 4). The approach described is satisfactory with one exception. It is indicated that for closely spaced frequencies the peak modal responses may occur at practically the same time, and normally the sum of the absolute values of the contributions from each mode is taken. Because of the interaction with the fluid, the modal responses are coupled. For this case, the approach indicated by the applicant of using the square root of the sum of the squares of all the modal responses is generally acceptable. In Amendment 3, page 3.3-18, the applicant advises that for the Zimmer plant a time-history analysis of reactor internals will be made. We concur in this approach.

The general stress criteria described for buried piping (Section A.3.1.1.3) and Appendix J, which will incorporate the effects of the ground motions, are acceptable. Careful attention should be given to points where piping enters or leaves structures or other points of constraints to insure that the piping does not undergo excessive local strain in these regions.

Critical Controls and Instrumentation

The seismic design criteria applicable to critical controls and instrumentation are described briefly in the PSAR on page D.6-3 (et seq.) (Amendment 7). Analysis and vibration test procedures are to be used to demonstrate the capability and adequacy of the equipment items. The results tabulated in the PSAR indicate that for items with reasonable amounts of damping, the performance exhibited meets the plant design criteria. For other items, which are covered by procedures outlined in Appendix I, it is noted that the seismic analysis and/or test results submitted by vendors will be examined in detail for acceptability. We believe the criteria outlined are satisfactory.

CONCLUDING COMMENTS

As a result of our study of the PSAR and related materials, we conclude that the seismic analysis and criteria to be employed in the design of the William H. Zimmer Nuclear Power Station are in accordance with the present state of the art and give reasonable assurance to provide structures with an adequate reserve of strength and ductility to resist seismic loadings combined with other applicable loadings.

REFERENCES

1. "Preliminary Safety Analysis Report", Vols. 1-5, and Amendments 1, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15, 16, 18, William H. Zimmer Nuclear Power Station, the Cincinnati Gas and Electric Company, et al., 1970 and 1971.

2. "Procedures for the Seismic Analysis of Critical Nuclear Power Plant Structures, Systems and Equipment", Report SL-2690, Sargent & Lundy Engineers, Chicago, 13 Nov. 1970 (Proprietary).