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27 September 1965

Mr. Edson G. Case
Assistant Director
Division of Reactor Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Re: Docket No. 50-237
Dresden Unit 2

File Copy (Original Only)

Dear Mr. Case:

Enclosed herewith are three copies of a draft of our report to the AEC Regulatory Staff on the subject, "Adequacy of the Structural Criteria for the Dresden Nuclear Power Station Unit 2." This report was prepared by Dr. W. J. Hall and myself and considers the various topics that we have discussed from time to time with you and representatives of your office. We shall be glad to have your comments on the draft. If there is any further activity that you wish us to perform on this topic, please let us know.

Sincerely yours,

N M Newmark

N. M. Newmark

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cc: Dr. W. J. Hall

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DRAFT

Report to AEC Regulatory Staff

ADEQUACY OF THE STRUCTURAL CRITERIA FOR THE DRESDEN NUCLEAR POWER STATION UNIT 2

by

N. M. Newmark and W. J. Hall

September 1965

ADEQUACY OF THE STRUCTURAL CRITERIA FOR
THE DRESDEN NUCLEAR POWER STATION UNIT 2

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INTRODUCTION

This report concerns the adequacy of the containment structures and components for the 715 MWe net Dresden Nuclear Power Station Unit 2, hereafter referred to as Dresden Unit 2, for which application for a construction permit and operating license has been made to the United States Atomic Energy Commission by the Commonwealth Edison Company. The facility is located along the Illinois, Des Plaines, and Kankakee Rivers, in Grundy County, Illinois, about 40 miles southwest of Chicago, Illinois. Dresden Unit 2 will be constructed adjacent to, and to the west of, Dresden Unit 1.

Specifically, this report is concerned with evaluation of the design criteria that determine the ability of the primary and secondary containment systems to withstand a design earthquake of 0.1g maximum 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 0.2g design earthquake loading to the extent of preserving the ability to maintain the plant in a safe shutdown condition. In addition, the seismic design criteria for Class I internal equipment and piping are reviewed.

This report is based on information and criteria set forth in the Plant Design and Analysis Reports (PDAR), and supplements thereto, as listed at the end of this report. In addition, we have participated in discussions with the applicant, its consultants, and the AEC Regulatory Staff, in which many of the design criteria were discussed in detail.

DESCRIPTION OF THE FACILITY

Dresden Unit 2 is described in the PDAR as a 2,255 MWt (715 MWe net) single-cycle forced circulation boiling water reactor that produces steam for direct use in the steam turbine. The fuel consists of UO_2 pellets in sealed Zircaloy-2 rods, and water serves as the moderator and coolant. The reactor vessel is about 21 ft in diameter, 68 ft high, and is to be made of SA-302 Grade B steel with Type 304 stainless steel interior cladding. The reactor vessel and the recirculation system are contained inside the drywell of a pressure suppression containment system.

The primary containment system consists of the drywell, vent pipes, and a structure shaped like a torus containing a pool of water; the center of the torus lies slightly below the bottom of the drywell. The drywell is a steel pressure vessel with a lower spherical portion about 66 ft in diameter and an upper cylindrical portion about 37 ft in diameter; the drywell is about 113 ft high, and the shell and head are to be made of SA-212 or SA-201 steel plate manufactured to A-300 requirements. The drywell is enclosed in reinforced concrete for shielding purposes, and to provide additional resistance to deformation and buckling; above the transition between the spherical and cylindrical portions of the drywell, we understand that the shell is separated from the concrete by a gap of several inches and that the backup filling material has not as yet been finally selected. Shielding at the top of the drywell is provided by a removable, segmented, reinforced concrete shield plug. The drywell contains one double-door air lock and one bolt hatch for access, in addition to the drywell head. The primary containment system is described in detail in Section V-3 of PDAR Volume 1.

646.4

The reactor building encloses the primary containment system; this building together with the standby gas treatment system and the 300-ft stack provide the secondary containment barrier. The reactor building houses the refueling and reactor servicing equipment, new and spent fuel storage facilities, and other reactor auxiliary or service equipment. From the standpoint of safeguard and containment, the primary purpose of the secondary containment is to minimize ground level release of airborne radioactive materials and to provide for controlled elevated release of such materials through the stack under accident conditions. As such, the reactor building, or secondary containment, is designed as a controlled-leakage structural system. The reactor building is founded on rock. The substructure consists of poured-in-place reinforced concrete exterior walls up to the refueling floor. Above this floor level the structure is steel framed with insulated metal siding installed with sealed joints. Interlocked double doors provide entrance to the building. The secondary containment system is described in detail in Section V-4 of PDAR Volume 1.

SOURCES OF STRESSES IN CONTAINMENT STRUCTURES AND TYPE 1 COMPONENTS

The primary containment system, which includes the drywell, vents, torus, and penetrations, is to be designed for the following conditions: pressure suppression chamber (torus) and drywell internal design pressure, +62 psig, -2 psig; initial suppression chamber temperature rise, 50°F. As noted on page V-6-1 of PDAR Volume 1, the aseismic design of the primary containment system, which is classified as a Class I--Critical Structure, will be based on dynamic analyses using response

646.5

spectrum curves corresponding to a 0.1g design earthquake. It is further stated that the design will be such that a safe shutdown can be made during a ground motion of 0.2g, or in other words an earthquake with twice the intensity of the 0.1g design earthquake. It is also noted that all structures will be designed to withstand a wind velocity of 110 mph, and that where failure possibly could affect the operation and functions of the primary containment and reactor primary system, the design will be made to assure that safe shutdown can be achieved under damage arising from the forces of short-term tornado loadings up to 300 mph.

The secondary containment system, consisting of several parts as described earlier, is considered a Class I--Critical Structure. The reactor building is to be designed to withstand an internal pressure of 7 in. of water (about 1/4 psi) without structural failure and without pressure relief; however, it is noted that there are means of providing reactor building pressure relief in the event of piping rupture, to assure building structural integrity. It is not clear to us how such relief will be handled, but the matter does not appear to be a major design problem. The aseismic design of the structure will be made for forces (supposedly coincident with dead load, snow load, and other applicable operating loads) corresponding to a design earthquake of 0.1g maximum ground acceleration. The design is to be made such that safe shutdown can be achieved for an earthquake motion of twice this intensity. The building is founded on rock, and geologic evidence indicates that any existing faults are inactive. The structure is to be designed to withstand a wind velocity of 110 mph, with the provision that irrespective of any particular damage

646.6

to the building, safe shutdown of the reactor can be achieved for tornado loading corresponding to winds up to 300 mph.

Amendment No. 4 of the PDAR notes that the 300-ft stack, which is part of the secondary containment, is to be considered also as a Class I structure. Accordingly, the stack, which currently exists as a part of Dresden Unit 1, must be capable of resisting the forces arising from the same design earthquakes and winds just described for the reactor building, in conjunction with other applicable loads.

The critical piping and equipment falling within the classification of Class I--Critical Structure or Class I--Critical Equipment, as listed in Section V-6 of Volume 1 of the PDAR, are to be designed to withstand the same seismic forces as noted earlier for the primary and secondary containment structures, in conjunction with other applicable loadings.

COMMENTS ON ADEQUACY OF DESIGN

Seismic Design Criteria -- In connection with the selection of the design earthquake, we agree with the approach adopted, namely that of basic design for a design earthquake of 0.1g, with the provision that a safe shutdown can be made for an earthquake of twice this intensity. We are in agreement with the soundness of this approach as presented by the applicant.

The design spectrum presented in Fig. 54 of PDAR Volume 3, which is identical to Fig. II-15-1 of Amendment No. 2, was examined in detail by us and appears to be acceptable in the light of a comparison with the 1940 El Centro earthquake. The latter has a maximum acceleration

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of 0.33g; the design earthquake used is approximately 0.3 times the intensity of the El Centro earthquake.

In Amendment No. 4 to the PDAR, in reply to Question 19, it is noted that both horizontal and vertical earthquake loads are included in each of the three representative examples, and that the vertical acceleration is taken as 2/3 the horizontal ground acceleration. We interpret this statement to mean that the same relative values of vertical to horizontal earthquake excitations will be used in all cases where seismic design is applicable.

In adding stresses arising from the different types of design loadings, that is dead load, pressure, wind, earthquake excitation, thermal effects, etc., in designing the containment structures and associated equipment, we believe that it is necessary to add directly (in terms of absolute numerical values) the stresses due to horizontal earthquake motions to those due to vertical earthquake motions, and to those due to pressure, temperature, dead load, and other operating loads as may be appropriate. On page II-15-2 of Amendment No. 2 it is stated that "for the design of Class I structures and equipment, the maximum horizontal acceleration and the maximum vertical acceleration will be considered to occur simultaneously. The resulting seismic stresses for the two motions will be combined linearly." In a discussion with representatives of General Electric and John A. Blume and Associates, we have ascertained that the interpretation of the foregoing statement is that maximum stresses which occur simultaneously at a particular location will be added directly in arriving at, or checking, the design. We concur in the approach.

For the earthquake of 0.2g maximum acceleration, it is indicated in Amendment No. 2 that in cases in which the material or structural elements are stressed beyond the yield point, calculations will be made to ensure that the energy absorption capacity available is greater than that which would correspond to the energy input from the earthquake. This approach appears reasonable to us in terms of limiting the deflections or distortions to permit proper functioning of critical pieces of the structure or equipment that are vital to a safe shutdown.

Two tables of damping coefficients are listed in the reports, one on page V-6-2 of PDAR Volume 1, and another on page II-15-2 of Amendment No. 2. We have been advised by representatives of General Electric and John A. Blume and Associates that the table of values given on page V-6-2 of PDAR Volume 1 will be those used in the design. We concur that the values given there are reasonable and conservative for use in the present design.

The seismic criteria employed in the design of the existing 300-ft stack, now a part of Dresden Unit 1, are described in Amendments No. 2 and 4. The procedures employed in the early design are not as accurate as the more rigorous analysis procedures proposed by the applicant for Dresden Unit 2. Amendment No. 4 indicates that a rigorous seismic dynamic analysis has been made of the existing stack; although only a brief summary of the results is presented, it appears that the stack possibly could be satisfactory in its present state, or with only minor modifications, in terms of meeting the Class I--Critical Structure design criteria. Interestingly, the base shear in the more rigorous analysis corresponded to 6.7 percent of the total weight of the stack, in contrast to 3.3 percent which was all that was required by the earlier procedure. The stack is noted to be relatively safe against overturning, and it is assumed, in accordance with presently accepted procedures, that the stresses arising from the overturning moments at various levels in the stack are combined directly with other applicable stresses in checking the design.

It is indicated that the earthquake design will be based on ordinary allowable stresses as set forth in the applicable codes, and that a one-third increase in the allowable working stresses because of the earthquake loading will not be used. Furthermore, it is indicated that Class II items will be designed following the normal practice for the design of power plants; as a minimum the seismic design will not be less that that given in the "Uniform Building Code" for Zone 1. We concur in these approaches.

No details are given concerning the possible strengthening of the areas around the penetrations of the containment, particularly the primary containment. Especially in the case of the large penetrations, care should be taken to ensure that these items will maintain the required strength and ductility under earthquake loading.

One final matter requires comment, namely the lack of compatibility in terms of seismic design between Dresden Units 1 and 2. Dresden Unit 1 will be significantly less resistant to earthquake forces than Unit 2. It is possible that steps could be taken to upgrade the seismic resistance of Unit 1 to that of Unit 2. However we have not considered this as a part of our evaluation of Unit 2 except as concerns the common stack for the two units.

646.10

Primary and Secondary Containment Structures -- General criteria covering the design of the primary and secondary containment structures are covered in various sections of the PDAR and supplements thereto. In Table 19-1 of Amendment No. 4 the allowable stresses for two combinations of loadings for the drywell (part of the primary containment system) are listed. The stresses noted appear to be in accordance with the applicable ASME codes, wherein rather high pseudo-elastic computed stress values are allowed for some stress combinations at locations of structural discontinuity, in the realization that local yielding will take place.

The allowable stresses for the reactor building for several load combinations are presented in Table 19-2 of Amendment No. 4. These appear to be in agreement with applicable codes, or in all other cases appear reasonable to us.

The selection of a wind velocity of 300 mph as being applicable in a tornado could be questioned. A value of as much as 500 mph appears more reasonable. Probably this higher velocity would not affect the design of the primary containment structure or the ability to achieve a safe shutdown, however. On the other hand, no evidence has been presented regarding this point, nor regarding the ability of the stack to resist tornadic winds.

Class I Piping -- Throughout the PDAR, frequent reference is made to meeting ASME and ASA code provisions. A tabulation of allowable stresses for a typical Class I piping situation is presented in Table 19-3 of Amendment No. 4. The stress values presented are in accordance with the ASA B31.1-1955 Code for Pressure Piping, and also permit rather high

646.11

stresses for self-limiting stresses such as thermal stresses. In general the approach and values given appear reasonable.

The details of the pipe penetration design are discussed on page V-3-3 of PDAR Volume 1 and Fig. 48 of PDAR Volume 3, and appear to be reasonable and consistent with other designs of this type for both high-temperature and cold lines.

It is assumed that the critical Type 1 piping tie-downs and supports will be adequate to resist the appropriate design loadings, including seismic loadings, and any jet thrusts arising from possible broken pipes. However no analysis of the effect of jet thrusts within the primary containment has been made available to us.

CONCLUSIONS

The design goal is to provide serviceable structures and components with a reserve of strength and ductility (a margin of safety) that will permit the structures and components to behave successfully under possible extreme loadings. On the basis of the information with which we have been supplied, we believe the design criteria outlined for the primary containment, secondary containment structures, and Type 1 piping, will provide an adequate margin of safety for seismic resistance.

We fully appreciate the present lack of compatibility as regards earthquake resistance between Dresden Units 1 and 2, and suggest that consideration be given in the future to upgrading the seismic resistance of Dresden Unit 1.

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REFERENCES

1. "Plant Design and Analysis Report -- Volume 1," Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company, 1965.

2. "Plant Design and Analysis Report -- Volume 2 -- Drawings," Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company, 1965.

3. "Plant Design and Analysis Report -- Volume 3 -- Plant Site and Environs," Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company, 1965.

4. "Plant Design and Analysis Report -- Amendment No. 2 -- Answers to AEC Questions," Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company, 1965.

5. "Plant Design and Analysis Report -- Amendment No. 4 -- Answers to AEC Questions," Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company, 1965.