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21 March 1969

Dr. Peter A. Morris, Director
Division of Reactor Licensing
U. S. Atomic Energy Commission
Washington, D.C. 20545

Re: Contract No. AT(49-5)-2667
Dresden Nuclear Power Station Units 2 and 3
AEC Docket Nos. 50-237 and 50-249

Dear Dr. Morris:

We are transmitting herewith a draft of our report concerning the Operating License Review for Dresden Nuclear Power Station Units 2 and 3.

We have attempted to incorporate into this draft, at least in modified form, all of the major points raised in our previous communications concerning the Operating License Review for this facility. In addition to the FSAR, additional informal information has been made available to us during the past six months. We regret that, on the basis of the information made available to us, we find it impossible to pass judgment on the adequacy of this design, as you will note in the concluding comments of the report.

We shall be pleased to discuss this report further with your staff as appropriate.

Sincerely yours,

N. M. Newmark

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bjw
cc: W. J. Hall
J. E. Haltiwanger
W. H. Walker
Enclosure

rec'd in files 1-12-72
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# REPORT TO AEC REGULATORY STAFF

# ADEQUACY OF THE STRUCTURAL DESIGN FOR DRESDEN NUCLEAR POWER STATION UNITS 2 AND 3

Commonwealth Edison Company

AEC Docket Nos. 50-237 and 50-249

by

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W. H. Walker

March 1969

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# ADEQUACY OF THE STRUCTURAL DESIGN FOR DRESDEN NUCLEAR POWER STATION UNITS 2 AND 3

Commonwealth Edison Company

by

N. M. Newmark, W. J. Hall, W. H. Walker

## INTRODUCTION

This report on the Dresden Nuclear Power Station Units 2 and 3 was prepared on the basis of: (1) a review of the Safety Analysis Report (SAR) and amendments thereto as submitted by the Commonwealth Edison Company, as listed at the end of this report; (2) a visit to the site on May 24, 1968; (3) review of several informal reports made available to us concerning the dynamic analyses; and (4) discussions of the facility with the AEC Regulatory Staff.

Dresden Nuclear Power Station Units 2 and 3 are designed for a maximum output of 2527 MWt (809 MWe net) each, and consist of single-cycle forced circulation boiling water reactors producing steam for direct use in the steam turbine. The two units are in most respects essentially identical, and are constructed adjacent to and west of Dresden Unit 1. The buildings are founded on rock. The facility is located at the confluence of the Illinois, Des Plaines and Kankakee Rivers in Grundy County, Illinois, about 40 miles southwest of Chicago.

The plant was designed for a Design Basis Earthquake of 0.20g maximum horizontal ground acceleration and for an Operating Basis Earthquake of 0.10g maximum horizontal ground acceleration. The vertical earthquake excitation was assumed to occur simultaneously, and was taken as two-thirds of the magnitude of the corresponding horizontal excitation.

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The criteria applicable to the design of Dresden Units 2 and 3 were reviewed extensively by us at the construction permit stage; we have not included herein comments on topics covered in our earlier reports dated September 1965 (Ref. 2) and July 1966 (Ref. 3) unless there was some specific reason for doing so.

## COMMENTS ON ADEQUACY OF DESIGN

### Dynamic Analyses of Structures

In addition to the SAR and its amendments, informal information was made available by the applicant in response to some of our questions specifically concerned with the methods of dynamic analysis.

The method of dynamic analysis for the major structures, that is, the ventilation stack, drywell, reactor-turbine buildings, and the reactor pressure vessel system has been described by the applicant in general terms. For the first three items a time-history solution of the governing equations, formulated on the basis of the stiffness approach, appears to have been made. The method for solving these equations was based on a classical normal mode approach for uncoupling the equations. The time-history of response was computed making use of a numerical integration of the Duhamel integral. Thus, the analysis presumably involved the computation of the classical normal modes and associated natural frequencies, the integration of the Duhamel integral for each appropriate mode, and a computation in some manner of the modal participation factors. Finally the modal response values were combined.

With regard to the over-all problem of evaluating the results of the analysis, the information from all available sources is not sufficiently complete to judge the adequacy of the results. Specifically, there are several items of pertinent information which are not available to us. These may be summarized as follows.

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1. The time-history for the input motion that was employed. We assume that a specific earthquake record was used in a scaled form, but this was not identified, nor was the length of the record time given that was employed.

2. To judge the adequacy of the computed combined response, the response spectra that result from employing the particular input time-history is needed for the several values of damping used. We have seen no calculation or result of this sort.

3. To judge the adequacy of the analysis of the ventilation stack, information is needed as to whether the stack was considered to be fixed against rotation at its base. We infer from some of the data we have seen that this was the case.

4. The technique for handling the combined analysis of the drywell and the reactor building is not clear. It appears that a rigid linkage was assumed between the drywell and the reactor building at elevation 575 ft. Other information available suggests that the drywell model was analyzed independently of the entire drywell and reactor building-turbine building system.

5. In response to Question 2.16b of the amendment to the SAR entitled "Answers to AEC Questions, Dresden Nuclear Power Station Units 2 and 3, Amendment No. 7 for Unit 2 and Amendment No. 8 for Unit 3" it is stated that "The participation factors are not involved in the analysis because either a time history analysis was used as outline (sic) in answer to Question 2.16, or a modal analysis, taking the square root of the sums of the squares with each mode participating equally, as outlined in answer to question 2.9 was used. The mode shapes are not plotted in the analysis." This response seems to be at variance with the general theory outlined in the descriptions of the

specific dynamic analyses. Since the time history was applied to the classical normal mode responses, it is obvious that participation factors are involved, although for one particular scaling of the modal responses one could make all the participation factors equal, and specifically equal to one. However, to do this requires a calculation, the results of which are not given. To say only that each mode participates equally is a meaningless statement.

6. The response to Question 2.16c, in the amendment just cited, which is concerned with the method employed in combining the modal responses notes that "The response of each mass for each mode considered at each increment of time is retained in the computations and the total response for each increment of time is obtained through the algebraic sum of each mass points model (sic) contribution at that particular instant of time..." Since individual modal response values are being retained at each increment of time and subsequently added, then obviously these components inherently contain the participation factors. We assume here that the classical uncoupled modal responses have, in fact, been used and not a numerical integration of the entire system as a unit. The latter would, of course, not require the so-called participation factors. It is not clear, however, whether only the deflections were computed by this method and other responses determined from the deflections, or whether each value of moment, shear, etc., was computed by summing the modal responses for that quantity at each time instant, and reporting the maximum value. To judge the adequacy of the results the specific modal maximum responses for moment, shear, deflection, etc., at each critical point should be available for examination.

Containment Design

On an over-all basis there is little information given on which to judge the adequacy of the structural design. For example, even if it is

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assumed that the dynamic analyses were sufficient and complete, then how were these forces incorporated into the design along with the other applicable loadings? Were the original criteria met in all cases? There should be provided, at the minimum, a discussion of the design procedures employed, comments on the latter with regard to the criteria, and possibly some examples for clarification. Without a presentation of this type, given in some detail, it is impossible to pass a reasoned judgment on the adequacy of the design.

Class I Structures Located Within Class II Structures

Of concern are those Class I structures, systems and components which are apparently contained or supported within Class II structures. Specifically such items might include the control room, standby gas treatment system, standby electrical power systems, diesel generators, and other electrical gear for power equipment. It is noted in Amendments 7 and 8 that such Class II structures were investigated to insure that the integrity of the Class I items is not compromised. Further clarification is supplied in Amendments 9 and 10 where it is noted that various emergency cooling water pumps that are located in Class II structures have been afforded Class I protection. How this was done is not clear to us. Also it is noted that the floor slab above the pumps protects them from debris and missiles during tornado type conditions and that the surrounding structure in this area of the station has been calculated to be earthquake resistant. To what degree it is earthquake resistant is not evident. It is noted that the intake suction line for the above-mentioned pumps running from the cribhouse to the turbine building is a steel pipe encased in concrete and meets Class I stress analysis requirements. However, no indication of the method of analysis or criteria employed to demonstrate that it meets Class I standards is given.

Torus Assembly and Suction Header

Of concern in review of the plant design is the dynamic analysis of the suction header which is concentric with the torus-shaped pressure suppression chamber. Apparently a modal analysis was performed for this system and as a result it was noted that "the analysis indicates 12 hydraulic snubbers are required." With respect to this aspect of the design, the results presented on page 2.7-2 of Amendments 7 and 8, wherein natural periods of vibration, spectral acceleration values and associated maximum stresses are tabulated, raise additional questions. Specifically the natural periods for the first through sixth modes appear to be extremely closely grouped. Under these conditions the combination of modal responses becomes a bit complicated and special precautions are needed to avoid misleading or erroneous results. The answer would have been more meaningful if the mode shapes had been identified. Thus it is difficult to evaluate the results of this seismic analysis. Also the question is raised, since the analysis indicated that twelve hydraulic snubbers were required, whether the system was re-analyzed to determine the effect of the snubbers on the response.

A question in this regard was also raised concerning the location and method of attachment of the suction header to the torus. These details are clarified in Amendments 7 and 8. The detail of the typical header support assembly, Fig. 2.8c, appears to be satisfactory. However, details of the installation of the snubbers and their effect on system response is not presented.

Dynamic Analysis and Design of Piping

The applicant has provided in Amendments 7 and 8, Question 2.9, a description of the seismic design of piping. Therein it is noted that a dynamic analysis was performed on the main steam lines, feed water lines, and recirculation piping. It is noted that a mathematical model consisting of lumped masses and elastic joining members was used and that the frequencies and mode shapes for the first seven modes of vibration were determined. Insufficient information is available to judge the adequacy of the approach. The piping involves a complex three dimensional system and it is not clear which modes will contribute significantly in the analysis or whether seven modes are indeed sufficient to define the dynamic response of the system.

The computation of the inertia forces is noted on page 2.9-3 of Amendments 7 and 8; these forces Q are computed from the relation Q = KV in which K is the stiffness matrix and V is the square root of the sum of the squares of the modal deflections. This relation is quite conservative for some internal forces but can give values of moments and stresses at specific points which might be much too low. It fails at points where there can be large relative deflections between nearby points, as has been verified by independent analyses.

With regard to the specific recommendations made on pages 2.9-6 and 2.9-7 of Amendments 7 and 8 the following are noted:

(1) The piping systems lateral supports are "designed to avoid the resonant range of the supporting structure." This raises the question of precisely what supporting structure input was considered. On page 2.9-2 it was noted to correspond to the idealization of the reactor building for a response spectrum corresponding to "Mass 6 N-S direction with 0.005 damping ratio." It is noted that this was chosen because it resulted in the "maximum response for the pipe systems." From these statements it is inferred that a single input from the main structure was used for the entire piping analysis.

Apparently the question of different inputs for different piping support points was not considered.

(2) The deflection between lateral supports is checked against a limit of L/480. The origin of this deflection limit is not explained.

(3) It is noted that the span between lateral supports was to be checked against an allowable span limit for a horizontal load of 0.5g and that the seismic stresses are not to exceed 1500 psi. This latter statement raises the question as to whether the piping was designed in part on the basis of a 0.5g loading and checked with a more rigorous analysis, or whether the piping was sized in part on the basis of the actual seismic loadings obtained in the formal analysis.

Finally, it is stated on page 2.9-7 that the location of snubbers was based "...upon engineering judgment satisfying stress and deflection limitations before the analysis is performed. If the original snubber location is proved to be unsatisfactory, additional snubbers are added at points of maximum deflection or snubber locations are changed in order to bring stresses within the criteria." It is not clear from these statements whether a revision in the analysis also was made after the snubber locations were changed. Also the statement is made again on page 2.9-7 that "consideration is given to magnification of response due to installed elevation, valves, branch lines, and bends." It is not clear whether a substantial magnification resulted from these considerations. Further clarification on all these points is needed.

Pump Flooding

It is noted that there are a number of motor-pump units located on the lower levels of the reactor building. Since many of these units are vital to safe shutdown and containment in the event of an accident, the question was raised as to what steps have been taken to provide protection from flooding due to leakage from the torus or from associated piping systems. A response has been provided in Amendments 7 and 8, Question 2.6. The reply states that because of certain design considerations the "rupture of this low pressure system [that is, the torus and the suction header] is considered incredible." Further, it is noted that water leakage from valve stems, flanges, and other small sources would be handled by two floor drain sump pumps, each having what is apparently adequate capacity. It is further noted that physical inspection of the torus area is to be made approximately every eight hours, and also monitored with alarms in the control room. It is not clear whether the motor-pump units are isolated physically from flooding due to failure of the torus if it should occur.

Failure of Dresden Island Lock and Dam

The possibility of the failure of Dresden Island Lock and Dam, which would reduce the Kankakee River level to a level below that of the intake of the main cooling water canal, has caused concern. The possibility is raised that this failure could possibly occur as a result of an earthquake which disabled the Class II systems and made the availability of the ultimate heat sink for all units uncertain. The applicant has provided a response to this question in Section I.F of Amendments 9 and 10. In general, a detailed analysis of the consequences of this event seems to have been made and the results appear to be satisfactory. It is noted that several additional sources of water require the survival and operation of certain Class II systems. For example, it is noted on page I.F-3 that river water could be pumped to the isolation condensers by making use of diesel-driven fire pumps (or by bringing in local city fire trucks). Furthermore although the fire system is a Class II system, it is noted that parts of the system could meet the requirements of a Class I system. It is our recommendation that consideration should be given to the systems that should be strengthened to meet the requirements for a Class I system; it would seem that this aspect of the problem can be adequately handled with some additional planning and perhaps backfitting.

## Critical Instrumentation and Controls

No information is presented in the SAR and amendments concerning the seismic design criteria and methods that were employed in the design of critical controls, instrumentation, batteries, battery racks, etc., required for safe shutdown and containment for this facility, other than that the design of these items falls under the criteria for Class I components. By inference we conclude that the design of these items by the supplier and constructor met Class I requirements; however, we have no description of such criteria or similar evidence directly available to us.

## SUMMARY COMMENTS

After a careful review of the SAR, amendments thereto, and other material made available to us, we are forced to conclude that it is possible only to make the following statement as to the adequacy of the design of the Dresden Nuclear Power Station Units 2 and 3. It is conceivable that the design is adequate in terms of provision for safe shutdown for a Design Basis Earthquake of 0.2g maximum horizontal ground acceleration and to withstand otherwise the effects of an earthquake of half this magnitude. However, on the basis of the information presented it is not possible for us (a) to evaluate the design in comparison to the design criteria, nor (b) to arrive at a judgment as to the adequacy of the design and the probable margin of safety.

Before we shall be able to make any significant comment on the adequacy of the design or margin of safety thereof, we shall have to have much additional information of the type noted in this report, or alternatively it will be necessary for some one to furnish us with approximate supplementary analyses made in accordance with the requirements stated herein.

## REFERENCES

1. "Safety Analysis Report, Vols. I, II, III and IV, and Amendments 7, 8, 9 and 10, Dresden Nuclear Power Station Units 2 and 3, Commonwealth Edison Company," 1968 and 1969.

2. "Adequacy of the Structural Criteria for the Dresden Nuclear Power Station Unit 2, Commonwealth Edison Company," prepared by N. M. Newmark and W. J. Hall, under AEC Contract No. AT(49-5)-2667, September 1965.

3. "Adequacy of the Structural Criteria for the Dresden Nuclear Power Station Unit 3, Commonwealth Edison Company," prepared by N. M. Newmark and W. J. Hall under Contract No. AT(49-5)-2667, July 1966.