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ADEQUACY OF THE STRUCTURAL CRITERIA FOR THE MONTICELLO NUCLEAR GENERATING PLANT UNIT 1

by

N. M. Newmark and W. J. Hall

INTRODUCTION

This report is concerned with the adequacy of the containment structures and components for the Monticello Nuclear Generating Plant Unit 1, designed for a net electrical output of about 472 MWe, for which application for a construction permit and operating license has been made to the U. S. Atomic Energy Commission by the Northern States Power Company, Minneapolis, Minnesota. The facility is located 22 miles downstream from St. Cloud, Minnesota, and about 3 miles northwest of the village of Monticello, Minnesota, on the south bank of the Mississippi River.

Specifically, this report is concerned with the design criteria that determine the ability of the primary and secondary containment systems to withstand a design earthquake of 0.06g 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 maximum earthquake of 0.12g ground acceleration to the extent of insuring safe shutdown and containment.

This report is based on information and criteria set forth in the Facility Description and Safety Analysis Report (FDSAR) and 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

Monticello Unit 1 is described in the FDSAR as a complete nuclear power unit to be licensed for operation at power levels up to approximately 1469 MWt (472 MWe net). The unit will be a single cycle, forced circulation, boiling water reactor that produces steam for direct use in the steam turbine. In most respects the design will be essentially identical to that for Commonwealth Edison's Dresden Unit 2 and the Millstone Nuclear Power Station.

The primary containment system, which houses the reactor vessel and the recirculation system, consists of a drywell, vent pipes, and a torus shaped structure which contains a pool of water for pressure suppression purposes; 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 62 ft in diameter and a cylindrical upper portion about 30 ft in diameter; the over-all height is approximately 105 ft.

The reactor building provides secondary containment for the system when the primary containment is in service and serves as the primary containment structure during periods when the primary containment is open for servicing. The reactor building together with the standby gas treatment system and a 290 ft stack provide the secondary containment barrier. The secondary containment building is described in Section V-2 of the FDSAR Vol. I as consisting of poured-in-place reinforced concrete exterior walls up to the refueling floor, with a steel structural frame with insulated metal siding located above this floor. The siding is to be installed with sealed joints.

Section II-5 of Ref. 1 and Figs. II-5-3 through II-5-5 indicate that bedrock exists at about elevation 860 and 870 at the plant site, and that about 60-80 ft of predominantly grandular sediments with interbedded layers of lacustrine clay and glacial till overlie the bedrock. As noted in Amendment 6, on page V-2-2 (Revised 3/8/67) of the FDSAR, the building is founded on a layer of compacted granulated backfill overlying a hardpan which covers a rock formation.

SOURCES OF STRESSES IN CONTAINMENT STRUCTURE AND TYPE 1 COMPONENTS

The containment system, which includes the drywell, vents, torus, and penetrations, is to be designed for the following conditions, as noted in Section V-1 of Ref. 1; pressure suppression chamber, internal design pressure, +56 psig, external design pressure, +2 psig; drywell internal design pressure, +56 psig, external design pressure, +2 psig; design temperature of drywell and pressure suppression chamber, 281°F.

As noted in Section V-3 of the FDSAR, the seismic design of the primary containment system, which is classified as either a Class I--Critical Structure or Class I--Critical Equipment, is to be based on dynamic analyses.

All structures will be designed to withstand a wind velocity of 100 mph with gusts of 110 mph, and where failure possibly could affect the operation and function of the primary containment and reactor primary system, the design is to be made to insure that safe shutdown can be achieved, considering the effects of possible damage arising from a short-term tornado loading with winds up to 300 mph.

The reactor building, which comprises the secondary containment system along with the stack and gas treatment system, is listed as a Class I--Critical Structure. The reactor building is to be designed to withstand an internal negative pressure of 0.25 in. of water with respect to the outside atmosphere in neutral wind conditions. It is also designed to be able to withstand 7 in. of water (about 1/4 psi) without pressure relief. The structure is to be designed for seismic loadings combined with the applicable functional loadings (dead load, operating loads, snow load, wind load, etc.).

The Class I--Critical Equipment, which includes the nuclear steam supply system, and reactor cooling and standby systems, as well as a number of other items, as listed in Section V-3 of FDSAR, are to be designed to withstand the same seismic forces and other applicable loadings as noted earlier for the primary and secondary containment systems.

COMMENTS ON ADEQUACY OF DESIGN

Seismic Design Criteria -- We agree with the approach adopted, which is identical in principle to that adopted for Dresden Unit 2, namely that of a basic design for a design earthquake with provision that a safe shutdown can be made for a maximum earthquake somewhat larger than the design earthquake. Since, as noted in Amendment 6, the foundations of Class I structures and equipment rest on sound rock or an otherwise firm base, we are in agreement with the 0.06g design earthquake and 0.12g maximum earthquake criteria as given by the applicant in the FDSAR.

The answer to Question 8.4 of Amendment 6 discusses soil-structure interaction. We assume that the interaction loadings between the reactor building substructure and the surrounding soil will be considered in the design of the substructure for both static and dynamic loading conditions.

The response acceleration spectra for the design earthquake of 0.06g (as recommended by the applicant in the FDSAR) is presented as Fig. II 6-5, and is plotted therein to an arithmetic scale which makes it difficult to read, especially in the high-frequency (low period) regions. The applicant indicates his use of acceleration response spectra corresponding to a smoothed response spectrum for the Taft earthquake of July 21, 1952, N69°W, except in terms of amplitude, which has been scaled. A replot of the spectrum with arithmetic scale for both period and response acceleration has been presented in Fig. 8.5-3 in Amendment 6. A plot of these spectra on tripartite logarithm paper would facilitate comparison of the acceleration, velocity, and displacement response spectra, and would give more definitive values in the high-frequency region, particularly those intended for use periods less than [illegible] seconds.

The discussion on page II-6-4 of the FDSAR Vol. I indicates that if computerized methods of dynamic analysis are used the mathematical model may be subjected to an excursion through the modified Taft earthquake. We recommend that, if this method of analysis is employed, the time-history record be such that it will be in agreement with the smoothed response spectrum values to be used in design, as described above, throughout the entire frequency range.

In Section V-3 it is noted that the vertical acceleration is assumed to be equal to two-thirds the horizontal ground acceleration, and that for the design of Class I structures and equipment the maximum horizontal acceleration and the maximum vertical acceleration are considered to occur simultaneously, and, where applicable, stresses are added directly. We concur in this approach as amplified in answer to Question 8.6, Amendment 6.

For the maximum earthquake and safe shutdown, it is noted in Section V-3 that the functional load stresses combined with the earthquake stresses probably do not exceed yield stress; however, where calculations indicate that a structure or piece of equipment is stressed beyond yield, an analysis will be made to determine its energy absorption capacity and a review will be made to insure that any resulting deflections or distortions will not prevent proper functioning of the structure or piece of equipment. The same type of statement is made for the maximum earthquake. These criteria are reasonable as long as the design leads to assurance that the shutdown can be achieved under the maximum earthquake conditions.

A table of damping coefficients is given on page II-6-5. It is noted therein that for the "reactor-building (massive construction with many cross walls and equipment and providing only secondary containment)" a damping value of 5 percent is specified. Further elaboration on this point is given in answer to Question 2.8 of Amendment 4 and Question 8.7 of Amendment 6. As a result of recent considerations on our part and by others, we would be in agreement with this value for cases in which working stresses are no more than about one-half the yield point and in which there may be considerable cracking associated with the concrete structure. In the event that the concrete is not stressed to that level where it is considerably cracked, we would recommend a value of 2 or 3 percent as being more reasonable. In either case the degree of cracking affects the amount of leakage and must be consistent with the damping value used, since it affects the design.

Also listed therein is a value of 10 percent critical damping for ground rocking modes of vibration; the applicant states in reply to Question 8.8 of Amendment 6 that 5 percent damping will be employed in this case, and we concur with this value.

The applicant advises in Amendment 6 that the damping factors cited in Table II-6-3 are to be employed for both the design and maximum earthquake loading conditions. We concur in this approach.

In connection with the secondary containment as provided by the reactor building, statements in Section V-2 indicate that the siding is to be installed with sealed joints. The insurance provided against leakage is not clear to us for cases involving design or maximum earthquake loadings and, we believe, deserves further consideration.

On page II-6-5 the statement is made that Class II structures and equipment shall be designed on the basis of a minimum seismic horizontal coefficient of 0.10 with a one-third allowable increase in basic stress. Further amplification on this approach is provided in answer to Question 8.10 of Amendment 6 wherein the applicant indicates that a seismic coefficient of 0.05 will be used instead, and claims that this approach is conservative when considered in connection with the basic design earthquake proposed by the applicant. In accordance with the discussion presented in the amendment, we believe this approach is acceptable.

With reference to cranes, further eleboration on the deisgn of the cranes is presented in answer to Question 2.9 of Amendment 4. On the basis of the philosophy therein, that clamps and bumpers will be provided to prevent the trolley and bridge from being displaced during earthquake excitation, we believe that the design will be satisfactory.

The design of the stack is described in more detail in answer to Question 2.10 of Amendment 4, and we are in agreement with the criteria described there concerning the possibility of damage should the stack fail, and the method of analysis to be followed in the design for possible earthquake loading. We recommend that the damping to be employed in the design be consistent with the stress levels that are expected, and a damping value on the order of 2 or 3 percent be used unless significant cracking is envisioned in the response of the stack, which we expect would not be the case. The applicant advises in Amendment 6 that 3 percent damping will be employed, with which we concur.

We find no details concerning specific attention to the strengthening of areas around penetrations of the containment, particularly in the primary containment area, the drywell. In the case of large penetrations especially, care should be taken to insure that these details will retain the required strength and ductility under earthquake and service loading.

Primary and Secondary Containment Structure -- Tables of allowable stresses for the primary and secondary containment design are presented on pages V-2-3 and V-3-3 of FDSAR Vol. I. The values listed in these tables are either in agreement with applicable codes or in other respects are reasonable. Clarification of the statements (and footnote) concerning safe shutdown as given in these tables is provided by the applicant in answer to Question 8.13 of Amendment 6, and is acceptable to us.

A study of the FDSAR documents indicates that the piping meets the applicable ASME and ASA Code provisions, and no further comment is made herein on this matter. The pipe penetrations are similar to the previous Dresden 2 design, and in accordance with discussion in the FDSAR and Amendment 4, provisions are indicated to accommodate the jet forces resulting from postulated ruptures of any pipes within the containment. We also note and agree with the design approach followed for the main steam isolation valves as outlined on page 2.7-2 of Amendment 4 wherein the design is carried out for seismic effects on these values as well as the applicable piping.

CONCLUSIONS

In line with the design goal of providing serviceable structures and components with a reserve of strength and ductility, and on the basis of the information presented, we believe the design criteria outlined for the primary containment, secondary containment, and Type 1 piping can provide an adequate margin of safety for seismic resistance.

N M Newmark

REFERENCES

1. "Facility Description and Safety Analysis Report--Volume I," Monticello Nuclear Generating Plant Unit 1, Northern States Power Company, 1966.

2. "Facility Description and Safety Analysis Report--Volume II," Monticello Nuclear Generating Plant Unit 1, Northern States Power Company, 1966.

3. "Facility Description and Safety Analysis Report--Amendments 4 and 6," Monticello Nuclear Generating Plant Unit 1, Northern States Power Company, 1966.

4. "Adequacy of the Structural Criteria for the Dresden Nuclear Power Station Unit 2," Report to the AEC Regulatory Staff, by N. M. Newmark and W. J. Hall, September, 1965.

5. "Report on the Seismicity of the Monticello Nuclear Generating Plant Unit 1," U. S. Coast and Geodetic Survey, Rockville, Maryland, March 30, 1967.