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URBANA, ILLINOIS 61801

28 March 1968

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

Re: Contract AT(49-5)-2667
Surry Power Station Units 1 and 2
Virginia Electric and Power Company
(AEC Dockets No. 50-280 and 50-281)

Dear Dr. Morris:

We are forwarding herewith two copies of the revised draft of the above-noted report, prepared by Dr. N. M. Newmark, Dr. A. J. Hendron and myself. We shall be pleased to discuss this report further with your staff as appropriate.

Sincerely yours,

W. J. Hall

W. J. Hall

bjw
cc: N. M. Newmark
A. J. Hendron

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DRAFT

REPORT TO AEC REGULATORY STAFF

ADEQUACY OF THE STRUCTURAL CRITERIA FOR THE SURRY POWER STATION UNITS 1 AND 2

Virginia Electric and Power Company
(AEC Dockets 50-280 and 50-281)

by

N. M. Newmark,
W. J. Hall
and
A. J. Hendron, Jr.

February 1968

Revised 28 March 1968

ADEQUACY OF THE STRUCTURAL CRITERIA FOR THE SURRY POWER STATION UNITS 1 AND 2

by

N. M. Newmark, W. J. Hall and A. J. Hendron, Jr.

INTRODUCTION

This report concerns the adequacy of the containment structures and components, reactor piping and reactor internals, for the Surry Power Station Units 1 and 2, for which application for a construction permit has been made to the U. S. Atomic Energy Commission (AEC Dockets No. 50-280 and 50-281) by the Virginia Electric and Power Company. The facility is to be located in Surry County, Virginia on a point of land called Gravel Neck which juts into the James River. The site is approximately 30 miles northwest of Norfolk, Virginia and seven miles south of Williamsburg, Virginia.

Specifically this report is concerned with the evaluation of the design criteria that determine the ability of the containment system, piping and reactor internals to withstand a design earthquake acting simultaneously with other applicable loads forming the basis of the design. The facility also is to be designed to withstand a maximum earthquake simultaneously with other applicable loads to the extent of insuring safe shutdown and containment. This report is based on information and criteria set forth in the Preliminary Safety Analysis Reports (PSAR) and supplements and amendments thereto as listed at the end of this report. We have participated in discussions with the AEC Regulatory Staff and the applicant and its consultants, in which many of the design criteria were discussed in detail.

DESCRIPTION OF THE FACILITY

The Surry Power Station is described in the PSAR as a pressurized water reactor nuclear steam supply system furnished by the Westinghouse Electric Corporation and designed for an initial power output of 2441 MWt

(816 MWe net) for each unit. The reactor coolant system for each unit consists of three loops, each loop having components (steam generator, pumps, and piping) generally similar to those for Indian Point Unit No. 2. The reactor vessel will have an inside diameter of about 13.0 feet, a height of 42.3 feet, and is designed for a pressure of 2485 psig and a temperature of 650^{O}F. The vessel is made of SA-302 Grade B low alloy steel internally clad with type 304 austenetic stainless steel.

The reactor containment structure which encloses the reactor and steam generators for each unit, consists of a steel lined totally reinforced concrete vessel with cylindrical walls, a flat base, and a hemispherical dome. The cylinder will be about 126'-0" inside diameter with a 4'-6" minimum wall thickness. The spring line of the dome will be about 128 ft. above the inside surface of the foundation mat. The dome will have an inside radius of 63'-0" and a thickness of 2'-0".

The liner will be made of 3/8 in. carbon steel sheet conforming to ASTM A-432 Grade 60 specification having a guaranteed minimum yield strength of 32,000 psi.

The reinforcing in the cylindrical portion of the shell will consist of horizontal and vertical bars, and diagonal bars placed at 45^{O} to the horizontal in both directions in the plane of the wall to resist tangential shear. Radial shear will be resisted by stirrups or diagonal bars. The reinforcing will conform to ASTM A15 or ASTM A408 specifications. For size 14S and 18S bars the Cadweld method of splicing will be employed except for a minor number of splices which may have to be made by welding.

Personnel and equipment access hatches are provided for access to the containment vessel. In addition there are other penetrations for piping and electrical conduits.

The facility includes a cooling water intake structure located on the James River. The intake pumps discharge the cooling water into a paved canal approximately $1\frac{1}{2}$ mi. in length. The cooling water is approximately 16 ft. deep in the canal, and we believe the design to be adequate.

The information on the geology at the site indicates that the surface deposits are sediments of the Norfolk Estuarine formation of Pleistocene age extending to depths of about 50 to 80 feet. The upper 20 to 35 feet of this formation consists of layers of brown and mottled brown sand, silty sand, organic and inorganic silts and clays, with interspersed thin lenses of iron oxide cemented sands. The lower part of the formation consists of layers of gray sand, silty sand, and organic and inorganic silts and clays, many of which contain decayed vegetation and shell fragments. The Norfolk formation just described unconformably overlies the Chesapeake group of Miocene age. Within the site area, the surface of the Miocene sediments are estimated to be about 240 feet thick. This layer consists of compact very stiff tough clays, green to dark gray in color, with occasional compact sand and silt members. These soils are noted to be strong and stable with moderate to high shearing strengths. Underlying the Miocene sediments are Eocene, Paleocene and Cretaceous sediments estimated to be about 45, 55, and 800 feet in thickness, respectively. From seismic investigations about 2 miles southeast of the site, the location of the crystalline bedrock is estimated to be at a depth of about 1,300 feet below ground surface.

There is no known fault near the plant site. The nearest known major fault is located southwest of Richmond about 60 miles from the site.

SOURCES OF STRESSES IN CONTAINMENT STRUCTURE AND CLASS I COMPONENTS

The containment structure is to be designed for the following loadings: dead load of the structure including effect of hydrostatic pressure, ice and snow loads; internal pressure corresponding to a loss of coolant accident of 45 psig; an internal temperature of 280°F; wind loadings; tornados (for Class I structures and systems whose failure might prevent shutdown) for a tangential wind velocity of 300 mph, an external vacuum of 1.5 psig, and missiles; and seismic loads as described next.

The earthquake loading will be based on a design earthquake of 0.07g maximum horizontal ground acceleration. The reactor also is to be designed to allow safe shutdown under a maximum ground acceleration of 0.15g.

Class I piping and equipment will be designed for normal live loads combined with pipe rupture loads and earthquake loading. The reactor internals are to be designed to resist earthquake combined with blow-down loadings and other applicable loadings.

COMMENTS ON ADEQUACY OF DESIGN

Foundations

The containment structures are to be founded on the stiff Miocene clay layer at about elevation -45 to -50 ft. The fuel building is to be founded on pipe piles extending into the Miocene clays with the base of the structure on a continuous mat at about elevation 0. The auxiliary building is to be founded on a continuous mat at about elevation +2. The control area is to be founded on a continuous mat at about elevation +2. The basement floor of the turbine building will be at elevation +9 with the structure founded on a system of soil-bearing strip footings; the turbine-generator will be founded on pipe piles driven into the Miocene clays. The service building will be founded on spread footings in densely compacted granular backfill at about elevation +20.

The detailed foundation studies that have been completed indicate that the factor of safety against liquefaction occurring during the maximum credible earthquake (based on 0.15g maximum horizontal ground acceleration) is considered adequate for the foundations and drainage conditions proposed at the Surry site. We concur in this evaluation.

However, from the studies that have been made thus far it appears that there is a possibility of significant relative deformation in both the horizontal and vertical direction between various building components of this facility. The applicant advised in Amendment 8 that after evaluating pile test results to be conducted as a part of the foundation evaluation program, if the actual pile displacements are such that the design safety factors would be reduced (with reference to rattle space requirements), the fuel building foundation will be revised to assure that the clearance between buildings is adequate. Also, the design of piping running between buildings must include provision for withstanding the possible relative motions. We believe that the approach outlined by the applicant in Amendment 8 is satisfactory.

Seismic Design

The information presented in the Amendments to the PSAR indicates that the reactor will be designed to withstand within the elastic range, the effects of an earthquake based on a maximum horizontal ground acceleration of 0.07g. It is also noted that the reactor will be designed to allow safe shutdown under an earthquake based on a maximum horizontal ground acceleration of 0.15g. These values are in agreement with those given in the report of the U. S. Coast and Geodetic Survey (Ref. 5).

In the case of safe shutdown and containment under the maximum credible earthquake, we concur in the basis of designing for an earthquake based on 0.15g maximum horizontal ground acceleration. However, we believe that this criterion, coupled with the use of standard spectra, will not lead to design criteria in the velocity controlling region with the desired degree of conservatism. It is our recommendation that the design spectra for the maximum credible earthquake be based on a maximum horizontal ground acceleration of 0.15g and a maximum ground motion velocity of 9 in/sec. In this manner the spectrum can reflect a reasonable degree of amplification in the velocity controlling region, a region in which a small number of critical items fall with regard to design. These ground motion bounds will not lead to difficulties, in our estimation, with liquefaction in the foundation soils.

Our reason for recommending this additional degree of conservatism in the seismic criteria results from our evaluation of the site conditions which encompass large depths of sediment overlying basement rock. It is our belief that significant amplification might occur, and it is our recommendation that some degree of conservatism be incorporated in the design to account for such possible amplification.

The spectra presented in Figs. S9.15-1 and S9.15-2 reflect the above noted criteria and are acceptable to us.

The general method of dynamic analysis for the containment structures has been outlined in the PSAR and supplements and we concur in the approach described. However, further amplification concerning the method of handling damping is desired as noted next.

The damping factors to be employed in the dynamic analysis are summarized in Table 2.5-2 and in answer to Question 12.2.4(3) of Supplement - Vol. 2. For reinforced concrete the damping factor of 5 percent will be associated with stress levels at or slightly below yield and at least a moderate degree of cracking. Damping values of 10 percent, as noted in answer to the question cited would be associated with a high degree of cracking of the concrete. However, as noted in the discussion, the damping values are over-all values which include the damping in both the reinforced concrete structure and the soil. Indeed, in this situation with the containment vessel founded on the Miocene clay, one would expect a rather high degree of damping from the foundation system, and this damping by itself has not been singled out for attention in the PSAR and supplements and amendments. It would be our recommendation that damping including rocking of the containment vessel on soft soil not exceed 10 percent and the applicant concurs as noted in Amendment 10. We recommend that this high value of damping not be carried through to any systems involving piping.

General Design Provisions for Containment

The loading combinations and allowable stresses are discussed in the PSAR, Section 5 and in answer to Question 12.2.3 in Supplement - Vol. 2. We are in agreement with the load combinations noted. It is also stated that the maximum allowable stress and tension under Case 3, which includes the hypothetical earthquake, will be limited to 80 percent of the minimum tensile strength of the reinforcing steel which does not exceed 90 percent of the minimum yield strength of the reinforcing steel. This criterion is acceptable to us.

The design of the liner is discussed in the PSAR and in the supplement. It is noted that the attachment spacing will be such that the critical buckling stress will be above the yield point of the liner material. Moreover, it is noted that the limiting stresses will be in accordance with

Section 3 of the ASME Boiler and Pressure Vessel Code. We are led to believe from these statements that the stresses and strains will be limited to values below yield for both the design and maximum earthquake conditions. Hence we concur in the approach adopted.

The analysis and design of the penetrations, including the large penetrations, is described in the PSAR and supplements. We concur in the method of analysis for analyzing the stresses as described by the applicant. Attention is called to the necessity for providing continuity of loads and deformations from the stiffening ring surrounding the opening into the shell under the various loading conditions imposed.

Piping, Vessels, Supports, Reactor Vessel Internals, and Other Applicable Components

The discussion presented in Section 10 of Supplement - Vol. 2, and on p. S10.1-7 of Amendment 7, notes that piping and vessels will be designed in accordance with Westinghouse Report WCAP-5890, Revision 1, with modifications. We are in agreement with the approach outlined.

The criteria presented for the design of the reactor internals appears satisfactory to us.

CONCLUSIONS

In line with the design goal of providing serviceable structures and components with a reserve in strength and ductility, and on the basis of the information presented, we believe the design criteria outlined for the containment and other Class I components, including the reactor internals, piping, vessels, and supports, can provide an adequate margin of safety for seismic resistance.

REFERENCES

1. "Preliminary Safety Analysis Report -- Vols. 1, 2 and 3," Surry Power Station Units 1 and 2, Virginia Electric and Power Company, 1967.

2. "Preliminary Safety Analysis Report -- Supplement Vol. 1 and 2," Surry Power Station Units 1 and 2, Virginia Electric and Power Company, 1967.

3. "Preliminary Safety Analysis Report -- Amendments 1, 2, 3, 4, 6, 7, 8, 9, 10," Surry Power Station Units 1 and 2, Virginia Electric and Power Company, 1967 and 1968.

4. Additional submissions:

   a) Revised Report, Environmental Studies, Proposed Nuclear Power Plant, Surry, Virginia, by Dames and Moore, dated November 17, 1967.

   b) Report on Seismicity Analysis, Surry Nuclear Power Plant Site, by Weston Geophysical Research, Inc., dated April 3, 1967.

   c) Report on Test Pile Program, Surry Power Station, NUS-1424, by Stone and Webster, dated June 28, 1967.

5. "Report on the Seismicity of the Surry Power Station Site," U. S. Coast and Geodetic Survey, Rockville, Maryland,__________.