August 29, 1997

Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities
Nuclear and Advanced Technology Division
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, PA 15230

SUBJECT: TWO MAJOR ISSUES RESULTING FROM THE STRUCTURAL DESIGN REVIEW OF THE WESTINGHOUSE AP600 ADVANCED REACTOR STANDARD DESIGN

Dear Mr. Liparulo:

As a result of the recent August 4 to 15, 1997, structural design review of the AP600 standard design by the Nuclear Regulatory Commission (NRC) staff, two major issues, the adequacy of the nuclear island basemat and the fire water tank designs, were identified. As you know, the NRC staff concerns about the adequacy of the basemat design goes back over three years. In a letter dated November 4, 1996, design of the containment foundation basemat was one of three major issues discussed. However, the fire tank design concern is very recent, since neither the conceptual design, nor any structural calculations were presented to the staff until the meeting on August 11, 1997.

It has been our experience with these issues that the Westinghouse response to the staff's concerns has resulted in incremental changes to the design that do not measure up to later scrutiny by the staff. A detailed discussion of these issues and corresponding staff positions are provided in the enclosure. It is important that you consider all the design options including a change in the basemat thickness and a change in the fire water tank design concept.

If you have any questions regarding this matter, you can contact Joseph Sebrosky at (301) 415-1132.

Sincerely,

original signed by: David B. Matthews

Jack W. Roe, Acting Director
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

Docket No. 52-003

Enclosure: AP600 Structural Design Review

cc w/encl: See next page

DISTRIBUTION:
See next page

DF03

DOCUMENT NAME: A:BASMT-FWT.POS *See previous concurrence

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

OFFICE	PM:PDST:DRPM		D:PDST:DRPM		(A)D:DE		(A)ADT		(A)D:DRPM	
NAME	JSebrosky:sg		*TRQuay		*GLainas		BSheron		JWRoe	
DATE	08/26/97		08/22/97		08/22/97		08/ /97		08/29/97	

OFFICIAL RECORD COPY

Mr. Nicholas J. Liparulo
Westinghouse Electric Corporation

Docket No. 52-003
AP600

cc: Mr. B. A. McIntyre
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
P.O. Box 355
Pittsburgh, PA 15230

Mr. Cindy L. Haag
Advanced Plant Safety & Licensing
Westinghouse Electric Corporation
Energy Systems Business Unit
Box 355
Pittsburgh, PA 15230

Mr. S. M. Modro
Nuclear Systems Analysis Technologies
Lockheed Idaho Technologies Company
Post Office Box 1625
Idaho Falls, ID 83415

Mr. Sterling Franks
U.S. Department of Energy
NE-50
19901 Germantown Road
Germantown, MD 20874

Mr. Frank A. Ross
U.S. Department of Energy, NE-42
Office of LWR Safety and Technology
19901 Germantown Road
Germantown, MD 20874

Mr. Charles Thompson, Nuclear Engineer
AP600 Certification
NE-50
19901 Germantown Road
Germantown, MD 20874

Mr. Russ Bell
Senior Project Manager, Programs
Nuclear Energy Institute
1776 I Street, NW
Suite 300
Washington, DC 20006-3706

Ms. Lynn Connor
Doc-Search Associates
Post Office Box 34
Cabin John, MD 20818

Dr. Craig D. Sawyer, Manager
Advanced Reactor Programs
GE Nuclear Energy
175 Curtner Avenue, MC-754
San Jose, CA 95125

Mr. Robert H. Buchholz
GE Nuclear Energy
175 Curtner Avenue, MC-781
San Jose, CA 95125

Barton Z. Cowan, Esq.
Eckert Seamans Cherin & Mellott
600 Grant Street 42nd Floor
Pittsburgh, PA 15219

Mr. Ed Rodwell, Manager
PWR Design Certification
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94303

DISTRIBUTION: Letter to Mr. Nicholas J. Liparulo, Dated: August 29, 1997

Docket File
PUBLIC
PDST R/F
SCollins/FMiraglia, O-12 G18
BSheron, O-12 G18
JRoe
DMatthews
TRQuay
TKenyon
BHuffman
JSebrosky
DJackson
JNWilson
JMoore, O-15 B18
WDean, O-5 E23
ACRS (11)
GLainas, O-7 D26
GBagchi, O-7 H15
TCheng, O-7 H15
SHou, O-7 H15
SWest, O-8 D1
EConnell, O-8 D1
JHolmes, O-8 D1
TMarsh, O-8 D1

AP600 Structural Design Review

Nuclear Island Basemat

Background

During the review of the AP600 structural design conducted in early 1994, the staff raised a concern regarding the adequacy of using a 6-foot thick foundation mat with a relatively large plan-dimension to support the nuclear island structure. The nuclear island structure is laid out with intersecting shear walls giving it a rigidity that can be realized only after it has been constructed to about two stories above the basemat. Nevertheless, there are large basemat panels that will be subjected to foundation pressure under combined loads. Even under uniform soil condition, the foundation reaction is large; but under certain non-uniform soil conditions, the reactions could increase under critical basemat panels causing problems with shear stress.

This concern was designated as Open Item 3.8.5-9 and documented in the AP600 draft safety evaluation report (DSER) issued on November 1994. Through a series of meeting discussions and transmittals from late 1994 to mid 1996, Westinghouse was made aware of the potential for the mat thickness to be a critical item. On November 4, 1996, the staff issued its position letter of major issues for the civil engineering and geosciences branch, and in this position it was indicated that the mat design had to account for non-uniform foundation stiffness under the mat and the loads that will be encountered during various stages of construction. The position concerning the basemat is included below for reference.

The basemat was discussed further during a civil/structural review meeting that was conducted on August 4 through 15, 1997. The review conclusions from this meeting are also discussed below.

Previous Staff Position

The following information was contained in the November 4, 1996, position letter concerning the design of the containment foundation basemat:

> The issue of the existence of collocated hard and soft spots in soil has not surfaced for other standard designs because it had no safety impact on their foundation design. Currently, the thinness of the AP600 basemat, even with the consideration of additional shear reinforcement, make it unacceptable for the likely soil stiffness variability that can be reasonably expected to exist at a site. Additionally, considering the basemat design as a COL action item is not acceptable.

Enclosure

There are two options for Westinghouse to consider for resolving this issue:

a. Demonstrate that the final foundation basemat design can accommodate the effects of soil stiffness variations of hard and soft spots underneath the basemat.

b. Use different basemat thicknesses for a foundation with uniform foundation stiffness (such as rock sites) and for a foundation with non-uniform soil stiffness (such as soil sites with hard and soft spots). Submit the completed design of each basemat thickness for the staff review and approval.

Review Findings from August 4 through 15, 1997, Meeting

In Section 3.8.4 of the AP600 standard safety analysis report (SSAR), Westinghouse committed that (1) the design and analysis procedures for seismic Category I structures are in accordance with ACI-349 Code for reinforced concrete structures, and (2) the ductility criteria of ACI 318 Code, Chapters 12 and 21, are considered in detailing, placing, anchoring and splicing of the reinforcing steel. As a result of its review of design calculations for the foundation mat by Westinghouse, the staff identified the following findings:

1. According to the ratio of span to depth, the nuclear island foundation mat should be classified as deep flexural members and be designed for the requirements for deep flexural members. For deep flexural members, ACI-349 Code requires that the critical section for shear is to be located at 0.15 times the span length from the support edge with reinforcing steel over full span. The staff believes the forthcoming ACI-349 Code will incorporate the deep flexural member shear requirements of the ACI-318-89 Code and the ACI-318-95 Code. However, Westinghouse did not treat the foundation mat as a deep flexural member. The shear reinforcement considered in the design is based on much reduced shear force at a section which is further away at a distance of the effective depth of the mat. The revised amount of shear reinforcement would require the use of larger reinforcing bars which would be spaced at a distance not more than "d/2" throughout the length of the member.

2. According to Chapter 21 of ACI 318-95 Code, stirrups used as shear reinforcement have to be provided with a 135 degree hook at both the top and bottom faces of the foundation mat. However, only stirrups (90 degree hook at the bottom face and 135 degree hook at the top face) were provided by Westinghouse for resisting shear. The flexural steel is spaced at 6 inch on centers top and bottom. Therefore, the provision of 135 degree hooks is not practical. The 6 ft thick basemat does not appear to be constructable with such heavy reinforcements.

3. The basemat calculation was performed using soil stiffness variation in alternate spans. However, soil stiffness variation after two spans, instead of alternates spans, would increase the shear force in the large panels even further. This was not considered in Westinghouse design.

4. Following the large increase in the water inventory in the passive containment cooling tank which sits high on the top of the shield building, an analysis of the overall nuclear island model was conducted for one soil condition to verify the adequacy of the seismic response. This analysis indicated increases in overall shear and overturning moment. This increase was accounted for in the latest design. It should be emphasized, however, that certain variations in the soil stiffness could increase the overturning moment more, which in turn could increase the soil pressure.

Conclusion and Staff Position

Westinghouse has not demonstrated that its proposed basemat design is adequate with respect to the previously provided staff position. The current AP600 foundation mat design does not meet certain code requirements. Even if the design calculations are revised, there will still be uncertainty with respect to its capacity as a standard design. The AP600 basemat design is marginal at best, and the staff has identified a number of sources of uncertainty in the loading that can be imposed on the basemat. This potential for loading increase makes the design unacceptable for design certification for the full range of foundation stiffness variation. The basemat design should be of such a thickness that soil stiffness variation does not lead to any significant change in the reinforcement bars required. Based on this, the staff concludes that the basemat design has not been demonstrated to be acceptable. Westinghouse needs to consider an increase in basemat thickness so that the design can be demonstrated to be suitable for a full range of site conditions.

Fire Water Tank

Background

In order to resolve issues stemming from fire protection needs, Westinghouse has provided a design for the fire water tank (FWT). The FWT is an integral part of the roof structure of the passive containment cooling tank (PCCST). It consists of a 9 inch deep, stainless steel T-sections, slotted at the bottom to allow flow of water from one part to another, with stainless steel plates welded to the T-sections top and bottom. Thus, it is essentially a 9 inch deep box of water hung from the under side of the roof of the PCCST.

Review Findings

A number of issues arose during the staff review of this tank, and these are discussed below.

- Out of plane acceleration could increase vertical load by about 40 percent. This was not considered in the design.
- The code to be used for the FWT is ANSI N690. This code is meant to be used for linear members, and not plate members.
- In-service inspection of this tank is not feasible.
- Trans-granular cracking of the stainless steel plate areas sensitized by welding cannot be ruled out. This would cause leaking.
- Design of the top plate to be used to act as a formwork for the wet concrete was not complete.
- Studs connecting the stainless steel T-sections to the underside of the concrete roof are subject to shear as well as tension. Conventional shear connectors are used to transfer shear only. The need to use shear connectors in both shear and tension is not in accordance with any code.

Conclusion and Staff Position

The FWT design is incomplete and does not appear to provide for inservice inspection during an assumed 60 year life. Therefore, the staff is unable to conclude that the design is acceptable. Westinghouse needs to consider changing the design of the FWT.