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FROM: George E. Apostolakis, ACRS

DUE: 04/18/02

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FINAL REPLY:

TO:

Chairman Meserve

FOR SIGNATURE OF : ** GRN **

CRC NO: 02-0198

Travers, EDO

DESC:

Phase 2 Pre-Application Review for AP1000 Passive Plant Design

ROUTING:

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DATE: 03/20/02

ASSIGNED TO: NRR

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SPECIAL INSTRUCTIONS OR REMARKS:

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AUTHOR:	George Apostolakis		
AFFILIATION:	ACRS		
ADDRESSEE:	Richard Meserve		
SUBJECT:	Phase 2 Pre-Application Review for AP1000 Passive Plant Design		
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D.C. 20555-0001

March 14, 2002

The Honorable Richard A. Meserve
Chairman
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Meserve:

SUBJECT: PHASE 2 PRE-APPLICATION REVIEW FOR AP1000 PASSIVE PLANT DESIGN

During the 490th meeting of the Advisory Committee on Reactor Safeguards (ACRS), March 7-9, 2002, we completed our evaluation of the Phase 2 pre-application review of the Westinghouse AP1000 passive plant design, conducted by the NRC staff. This matter was also reviewed during joint meetings of our Subcommittees on Thermal-Hydraulic Phenomena and Future Plant Designs on February 13-15, 2002, and a meeting of the Subcommittee on Thermal-Hydraulic Phenomena on March 15, 2001. During our review, we had discussions with representatives of the Westinghouse Electric Company and the NRC Staff. We also had the benefit of the documents referenced.

Conclusions and Recommendations

1. The staff has made a competent and thorough review of the Phase 2 issues.

2. We agree that the proposal by Westinghouse to use Design Acceptance Criteria (DAC) for the piping design should be approved.

3. The staff's positions on the other pre-application review issues should also be approved.

4. The Office of Nuclear Regulatory Research (RES) should further investigate acceptable ranges of ratios of Pi-groups for use in scaling.

5. The ad hoc introduction of compensating processes to tune codes to the integral test data should be discouraged.

Discussion

The NRC staff and Westinghouse have agreed to a three-phased approach to the AP1000 standard plant design review. Phase 1, which was to identify the key review issues, was completed previously and resulted in the identification of four key issues:

1. Acceptability of the proposed use of DAC for particular parts of the design review.

2. Acceptability of certain exemptions that Westinghouse intends to request.

3. Applicability of the AP600 test program to the AP1000 design.

4. Applicability of the AP600 analyses codes to the AP1000 design.

The purpose of the Phase 2 review was for the staff to develop positions on these four key issues. These positions are discussed below.

Proposed Use of DAC

The Commission has determined that the level of detail in a design certification application must be sufficient to enable the Commission to judge the applicant's proposed means of ensuring that construction conforms to the design and to reach a final conclusion on all safety questions associated with the design.

The staff has interpreted this policy to mean that the certification application must be complete, with two exceptions:

- items for which the technology is rapidly changing and may be significantly different at the combined operating license (COL) stage.

- items for which the level of detail cannot be provided at the time of certification review (or for which the as-procured and as-built characteristics are needed).

For these exceptions, DAC are required of the applicant. Some precedents for DAC satisfying these criteria were established with the certifications of the Advanced Boiling Water Reactor (ABWR) and System 80+ designs. For these, the staff accepted DAC for the instrumentation and control (I&C) and for the control room design, both of which were deemed to satisfy one or more of the above criteria.

In addition to these two areas for which precedents have been established, Westinghouse has proposed DAC for the AP1000 piping design.

The staff has concluded that the DAC approach should be approved for I&C and control room portions of the design based on the two criteria above and that the DAC on piping design should be approved based on the similarity of AP1000 to AP600 designs, for which the certification included sufficient piping design detail.

While we have some sympathy with this view by the staff and agree that the piping DAC should be approved, we believe the piping DAC could have been approved without invoking the similarity to the AP600 design. Our view is that, as long as sufficient detail is available to permit resolution of safety questions, the degree of detail that an applicant wishes to provide at the certification phase is a business decision. We believe the use of DAC for the piping design fits this characterization.

Exemptions

Westinghouse is requesting exemptions from the regulations in three areas:

> (a.) Section 50.34 (f)(2)(iv) requires a "safety parameter display console that will display to operators a minimum set of parameters defining the safety status ... displaying a full range of important plant parameters ..., and capable of indicating when process limits are being approached or exceeded."
>
> (b.) Section 50.62(c)(1) requires that equipment be available to ensure the automatic startup of the auxiliary feedwater system under ATWS conditions.
>
> (c.) GDC 17 of 10CFR50 Appendix A requires two physically independent offsite power sources.

The staff agrees with the Westinghouse positions that: Item (a) will be part of the DAC for control room design; the underlying purpose of Item (b) is satisfied because AP1000 does not have (or need) an auxiliary feedwater system as the emergency core cooling system (ECCS) requirement is met by the passive residual heat removal (PRHR) system automatic initiation under ATWS; and that the underlying purpose of Item (c) is satisfied because, with the passive ECCS, AP1000 does not need offsite power to make its safety case. We also agree with these positions.

Applicability of AP600 Standard Plant Design Analysis Codes and Test Program

To address the applicability of the AP600 codes and test program, Westinghouse prepared a new AP1000 phenomena identification and ranking table (PIRT) and conducted new scaling assessments for both the codes and the tests. The AP1000 PIRT resulted in the same high- and medium-ranked phenomena as were found for the AP600, and it was noted that the AP1000 design did not entail any important new phenomena. In addition, the scaling analyses indicated that the Pi-groups identified as being important and which were to be substantially matched in the integral test program were still in the acceptable range when compared to their values for the full-scale AP1000 design. Thus, Westinghouse maintains that these results demonstrate that the AP600 test database used to validate the analysis codes is applicable to AP1000 and that the codes should be approved for use in evaluating the safety status of AP1000 design.

The staff conducted independent top-down and bottom-up scaling assessments and made audit calculations using RELAP5 for a postulated 2-inch diameter break in the cold leg and for a postulated double-ended direct vessel injection (DVI) line rupture. The staff found that, with some noted exceptions, the experimental data produced by the AP600 separate effects and integral effects test programs are appropriate for verification of the processes expected in an AP1000 plant, and the analysis codes validated for the AP600 standard plant design are applicable to the AP1000 design.

The most significant of the exceptions is that the tests are not considered sufficient to validate the entrainment model used in the NOTRUMP code for the upper plenum regions and for the hot-leg exit through the automatic depressurization system (ADS-4) depressurization valve.

Westinghouse claims that the scaling test data and analyses are sufficient to ensure that the core remains covered and that the entrainment is a self-limiting process that decreases as the core water level decreases. Westinghouse also claims that the period during which the entrainment is important in affecting the water level is so short that entrainment is not safety significant. We think such a case can be made during the certification review and, if so, additional tests would not be necessary.

Nonetheless, the staff's position has merit in that it will be necessary to better predict the entrainment behavior before judgments can be made regarding its safety significance. We believe phenomena that are ranked high or medium in importance should be properly treated in the models partly because unanticipated applications could invalidate the "non-safety-important" judgment. We remain concerned that the codes do not properly model entrainment because inapplicable maps are being used to characterize the flow regimes. The use of inapplicable maps could impact the results of the codes in unanticipated ways. Thus, we are convinced that the technical basis codes need better modeling with respect to entrainment and flow regime maps.

Other Considerations

In the scaling assessments, Westinghouse and the staff used the criterion that Pi-group ratios having values between 0.5 and 2.0 represent acceptable scaling. While this range is intuitively pleasing as an indication that the tests sufficiently match the phenomena in AP1000, we have not seen any technical justification for this criterion. Thus, we believe that RES should initiate a study with the objective of establishing a technically based approach for use in determining the significance of any general Pi-group. We think this would involve sensitivity analyses on the Pi-group in the non-dimensional scaling models. The sensitivity of the results to individual Pi-group ratios could guide the selection of acceptance ranges that might be different for different Pi-groups. Although we do not believe that this work is needed for AP1000 certification, this issue is likely to arise with certification of future reactor designs and such a study could tie down this loose end of the code, scaling, applicability, and uncertainty (CSAU) process.

There are two instances in which Westinghouse proposes to adjust its models to provide a better fit to integral data by introducing compensating processes. In one instance, the NOTRUMP code does not model the momentum flux terms in the conservation of momentum equations dealing with effects of area and density changes. This deficiency in the code impacts its ability to calculate pressurizer drainage and reactor vessel downcomer level. To compensate for this code deficiency in the AP600 certification, Westinghouse imposed a reduction in the in-containment refueling water storage tank (IRWST) level – thus reducing the driving force which would conservatively compensate for the effects that would have resulted from having the correct momentum equations. For the AP1000, instead of this same "fix," Westinghouse proposes to use an increased flow resistance penalty that would make the code calculations fit the APEX facility data for a 2-inch small-break loss-of-coolant accident (SBLOCA).

In another instance, Westinghouse concluded that the NOTRUMP PRHR model does not model the thermal plume in the IRWST. The model will over predict the outside surface heat transfer rate for the heat exchanger when the tube flow velocity exceeds 1.5 ft/sec for any

significant period of time. If this situation arises in the analyses, Westinghouse proposes to account for the non-conservative calculation by an ad hoc reduction of the predicted heat exchanger performance.

These temporary fixes should provide conservative results to support the certification of AP1000 design. Nevertheless, we view both of these as instances of purposeful introduction of compensating errors in the codes rather than improving the models. We consider it bad practice to allow these errors to persist in the codes and believe that the actual physics should be properly represented in the long term.

Sincerely,

George E. Apostolakis
Chairman

References:

1. Memorandum dated February 4, 2002, transmitting draft SECY Paper, undated, Subject: Use of Design Acceptance Criteria and Exemptions for the AP1000 Standard Plant Design (Predecisional), and draft SECY Paper, undated, Subject: Applicability of AP600 Standard Plant Design Analysis Codes and Test Program to the AP1000 Standard Plant Design (Predecisional).
2. Memorandum dated June 21, 2000, from John T. Larkins, ACRS, to William D. Travers, Executive Director for Operations, NRC, Subject: AP1000 Pre-Application Review.