UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OCT 6 1982

MEMORANDUM FOR: B. J. Youngblood, Chief, Licensing Branch No. 1, DL

FROM: W. F. Kane, Project Manager, Licensing Branch No. 1, DL

SUBJECT: SUMMARY OF SEPTEMBER 29-30, 1982 MEETING HELD BY INDEPENDENT DESIGN REVIEW GROUP - WESTINGHOUSE MODEL D2/D3 STEAM GENERATOR MODIFICATION

Background

At our request the three utilities that own plants with Model D2 and/or Model D3 steam generators have formed an independent design review panel (Panel) to review the Westinghouse program for correcting damaging tube vibration in these type of steam generators. The first meeting of the Panel and Westinghouse was held in Pittsburgh, Pennsylvania on June 30-July 1, 1982. NRC staff representatives attended that meeting and provided comments to the Panel. The meeting was attended by G. Lainas, T. Ippolito, W. Kane and J. Rajan of the staff and M. Wambsganns an ANL consultant for the staff.

Discussion

The second meeting of the Panel and Westinghouse was held on September 29-30, 1982. This meeting was attended by G. Lainas, W. Kane, J. Rajan and E. Murphy of the staff and M. Wambsganns and S. S. Chen, ANL consultants for the staff.

Some of the major items of interest from the meeting are as follows:

(1) Westinghouse has about two more weeks of work in order to produce their final report. One open item involves an elastic-plastic analysis of the manifold where certain areas of the design exceed allowable ASME Code stress limits.

(2) The test program has been completed and Westinghouse concludes that it confirms the adequacy of the manifold to reduce the vibration to acceptable levels.

(3) The Westinghouse tube wear models indicated that some of the tubes will reach the 40% plugging limit and will not be able to achieve a 40-year life even after the modifications are made.

(4) Westinghouse has analyzed the event in which the manifold becomes detached during plant operation and impacts the tubes. They concluded that no tubes would be ruptured.

(5) Westinghouse expects Almaraz Unit 1 to be the first plant modified.

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(6) The Panel expects to issue its evaluation on or about October 20, 1982 with plant specific evaluations about one week later.

(7) The Panel is projecting NRC staff approval on or about November 15, 1982.

Staff Comments

Near the conclusion of the meeting the staff was invited to comment on the modification program. The following comments were presented to the Panel by the staff and its consultants:

(1) All of the significant review topics have been identified.

(2) Significant progress has been made since the Panel's last meeting.

(3) The Panel's report should be as complete as possible highlighting the significant issues that were identified and their resolution. The report should emphasize the safety aspects of the design.

(4) The surveillance program will be one key to acceptability of the modification. This program should include the use of eddy current examination, internal instrumentation in the tubes and the pressure transducer in the feedwater line. The associated schedule and selection of limits should have a clear basis.

(5) The method of inspection and the inspection program for the manifold must be defined.

(6) The Panel should assess its capability to critically review the Westinghouse work in the area of elastic/plastic analysis and fracture mechanics. Consideration should be given to the use of outside consultants.

(7) The stress analyses should consider the effects of a main steam line break on the structural integrity of the manifold.

(8) There appears to be a number of open areas. If any still exist when the Panel issues its report they must be identified and the basis must be provided for proceeding while they are being completed.

(9) Many of the staff's comments from the June 30-July 1, 1982 meeting need to be resolved. All staff comments should be addressed in the Panel's final report.

(10) A realistic analysis of the effects of manifold detachment should be provided to assure that the consequences are acceptable. The panel should take a critical look at this analysis.

(11) The Panel and Westinghouse may be doing a lot of work that the staff is not aware of. This needs to be documented in the final report.

(12) The post-installation surveillance program to monitor tube wear should address the uncertainties in the wear rate projections. The Panel's report should address whether this program will be performed for the lead plants or all plants with Model D steam generators following manifold installation.

(13) The structural integrity of the manifold and the welds must be clearly established for all loading conditions including faulted conditions.

(14) The fatigue usage factors on some welds are quite high. If, in addition, it is assumed that there are fluctuating loads on the manifold the usage factors may be unacceptable. This must be evaluated by the Panel.

(15) One of the conclusions reached is that after 10 years of operation tubes in rows 45 thru 49 would undergo tube wear. As clearances increase vibrational loads could increase and other modes of vibration could come into play. The population of affected tubes could increase progressively.

(16) The tube support design including the diametral clearance is a critical factor in determining the vibrational characteristics of the tube bundle. The manifold effectively reduces the inlet turbulence. However, this only represents a partial solution. No modifications are being proposed relative to diametral clearance.

(17) Comparability between the 0.417 scale model and the SSPB facility as well as that between the 0.417 scale model data and plant data has not been demonstrated. Scaling factors have not been discussed in sufficient detail.

(18) Wear in the 10th and 12th support plates can be explained by 40 Hz sinusoidal motion in the inlet region. Tubes were undercut to simulate support conditions. However, it has not been shown that this is a unique solution. Other modes of vibration at other frequencies could produce similar wear patterns.

(19) In predicting tube wear, wear coefficients with values of 5 and 300 are used. It would seem that the wear coefficients should have a range of values.

(20) The non-linear dynamic analysis model used does not explain the high work rates between support plates 5 and 6.

(21) A 3.5 lb. sinusoidal force was assumed to explain tube motion at the edge of the impingement plate. There is no credible mechanism that would explain such a high vibrational load.

(22) SSPB test data is not yet available for review. The details of how the support conditions were varied and the results from such variations are of interest.

(23) Based on the available information, the tube excitation mechanisms can not be separated as clearly as Westinghouse has concluded.

(24) We need to understand what has been considered in the non-linear model in calculating the work rate, e.g., the indentation of tube and support plate during impact as well as the friction coefficient for sliding. The non-linear model does not include fluid gap damping. In addition, in modeling fluidelastic instability, fluidelastic force (proportional to tube displacement) is considered. In water flow, the fluid-damping force (proportional to tube velocity) may be more important and has not been considered.

(25) To eliminate the question of excitations other than in the inlet pass, flows entering spans between plates 6 and 7 and 4 and 5 can be tested in the 0.417-model.

(26) It was determined that some of data being used in the evaluation (in particular, ECT measurements) were out-of-date.

(27) Westinghouse has developed a design modification that successfully meets the goals of reducing inlet turbulence and achieving nearly uniform flow at the inlet. It must be determined whether this is sufficient.

(28) The root cause of the problem is the result of design features of large tube-to-tube support plate (TSP) clearance (24 to 30 mils diametral) and short spans (22, 8, 11 in.). These design features increase the probability that a tube may "float" in a particular TSP such that that TSP is effectively inactive, i.e., does not act as a support.

(29) The large clearance and short spans in combination with high cross-flow velocity can result in detrimental tube vibration. The design modification does nothing to remove the root cause of the problem. Also, the total flow rate into the bundle and flow distribution over spans away from the inlet span remain unchanged with the design modification.

(30) While the design modification reduces turbulence and smooths out the flow, the flow velocities are still relatively high, i.e., 8-9 ft/sec. Tests show 5 to 14 ft/sec. Both Westinghouse and ANL calculations indicate a potential for fluidelastic instability with an appropriate 40 Hz mode.

(31) There is a potential for fluidelastic vibration at the inlet as well as at spans away from the inlet. As an explanation of why fluidelastic vibration was not seen in SSPB tests, this may be due to the way the TSPs were offset. In addition, fluidelastic instability may be governed by drag force. The effect of flow over adjacent spans was not simulated in the SSPB model.

(32) There is a concern that the 0.417-scale-model test only simulates (through selective undercutting of tubes) one particular tube support configuration. Westinghouse argues that they are simulating the "worst case". We believe other tube support configurations should be examined.

(33) Westinghouse should investigate behavior at spans away from the inlet. They could do this by (a) undercutting tubes to encourage other "modes", (b) measuring flow velocities/distribution, (c) computing flow distribution with a 3-D thermal/hydraulic code.

(34) Neither of the tests (0.417-model or SSPB) can be considered confirmatory.

(35) It is felt that too much emphasis is being placed on the non-linear analytical model. Westinghouse concludes that turbulence is responsible for the majority of tube wear based on the non-linear model results. Westinghouse is doing some excellent (even pioneering) work in this area. However, it is our experience that, within limits, you can pretty much get what you want from such analyses.

(36) The non-linear analytical model is very useful for insight and guidance. Care should be taken in using it for much more than that; e.g., using it to predict 40 yr. tube life.

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SUBJECT: SUMMARY OF MEETING WITH WESTINGHOUSE REGARDING MODEL D4/D5/E STEAM GENERATORS

General

Representatives of the NRC staff and its consultant, Argonne National Laboratory met with Westinghouse to discuss the Model D4/D5/E steam generators. The meeting was held at the NRC offices in Bethesda, Maryland. A list of those persons who attended the meeting is included in the enclosure.

Purpose

The purpose of the meeting was to discuss the program for modifying these types of steam generators to preclude the damaging tube vibration which had been experienced on some Model D3 steam generators.

Discussion

Westinghouse described the basic physical differences between the Model D2/D3 steam generators and the Model D4/D5/E steam generators. The Model D4/D5/E steam generators have a different flow pattern for the main feedwater flow than the Model D2/D3 steam generators due to a different arrangement of the internal baffling. Consequently, the tubes in the Model D4/D5/E steam generators would be expected to have a different response than those in the Model D2/D3 steam generators. Westinghouse expects that some modification will be required for the Model D4/D5/E steam generators. However, based on the information to date they do not expect that the problem will be as severe.

Westinghouse also discussed the differences between the Model D4, D5 and E steam generators. There appear to be no differences which would preclude a similar solution to this problem for these types of steam generators.

The only operating plant in this category is the Krsko plant in Yugoslavia which uses Model D4 steam generators. This plant was modified in mid-1982 because of concerns related to tube vibration. The modification to that plant involved diverting 30 percent of the main feedwater flow to the auxiliary feedwater nozzle. However, it is not clear at this time that this modification will be applied to the remainder of the Model D4/D5/E facilities.

Westinghouse described the test facilities which are, or will be, used in the Model D4/D5/E program. Westinghouse expects that the modification for the Model D4/D5/E facilities will be selected in early 1983.

The domestic facilities employing Model D4/D5/E steam generators are as follows:

Facility	Model	Number of Loops
Braidwood 1	D4	4
Byron 1	D4	4
Comanche Peak 1	D4	4
Marble Hill 1	D4	4
Shearon Harris 1	D4	3
Shearon Harris 2	D4	3
Braidwood 2	D5	4
Byron 2	D5	4
Catawba 2	D5	4
Comanche Peak 2	D5	4
Marble Hill 2	D5	4
South Texas 1	E	4
South Texas 2	E	4

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Enclosure:
As Stated

LIST OF ATTENDEES

NRC Staff

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