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R. C. DeYoung, Assistant Director for Pressurized Water Reactors, Licensing
THRU: A. Schwencer, Chief, Pressurized Water Reactors Branch No. 4, Licensing

Original signed by
A. Schwencer

MEETING WITH DUKE POWER COMPANY AND BABCOCK AND WILCOX COMPANY - OCTOBER 25, 1972
B&W TOPICAL REPORTS ON THE SUBJECT OF REACTOR VESSEL INTERNALS - OCONEE UNIT 1

Enclosed is a summary of the meeting held on October 25, 1972 with Duke Power Company and the Babcock & Wilcox Company. An attendance list is also enclosed.

/s/

I. A. Peltier, Project Manager
Pressurized Water Reactors Branch No. 4
Directorate of Licensing

Enclosures:
1. Meeting Summary
2. Attendance List

cc: R. S. Boyd
D. Skovholt
D. Knuth
R. Maccary
H. Denton
PWR Branch Chiefs
R. W. Klecker
M. Rosen
RO (3)
D. Lange
C. Hou
H. Schierling
R. Bernero
B. Buckley
H. Faulkner
J. H. Sniezek
K. Wichman
K. Economos
U. Potapovs
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ENCLOSURE NO. 1

MEETING WITH DUKE POWER COMPANY AND BABCOCK & WILCOX COMPANY

MEETING SUMMARY

October 25, 1972

Summary

The questions raised by MEB on B&W topical reports BAW-10037, 10050, and 10051 and the answers presented at the meeting by B&W are enclosed with the original and related copies of this report (Docket File, Project Manager, MEB and PDR copies).

Although the topicals along with the supplemental information provided by B&W will permit MEB to complete its review of the Oconee Unit 1 internals redesign, approval of the topical reports depends on the success of Oconee Unit 1 tests. B&W and the applicant will receive letters stating the conditional acceptability of the reports.

Per Safety Guide 20, in order for Oconee Unit 1 to be a valid prototype B&W must establish its ability to predict the forcing functions which can be correlated with the response of the sytem. This effort requires a blending of theoretical and experimental work and because of the scaling problems the 1/6 scale flow model tests are not useful in establishing dynamic fluid characteristics for the large system. In this regard B&W stated that it is currently considering tests in a full scale vessel capable of testing full scale production guide tubes and nozzles. B&W is considering running both the old and the new design guide tubes and nozzles in this facility.

B&W also stated its intention to perform in air vibration tests on the new internals using the SMUD hardware at Barberton just as the old internals were tested during the failure investigation.

B&W suggested that thermal shield forcing functions may be developed from the original Oconee Unit 1 hot functional tests. These tests in conjunction with the full scale internals tests could in B&W's judgement provide the basis for establishing Oconee Unit 1 as a valid prototype per Safety Guide No. 20. Another possibility discussed is the instrumentation of the thermal shield in Oconee Unit 2. MEB reserved judgement on these approaches until it has had an opportunity to review the entire package of efforts being conducted by B&W. B&W said it would attempt to provide this package to the AEC by the end of November 1972.

ENCLOSURE NO. 2

MEETING WITH DUKE POWER COMPANY AND BABCOCK AND WILCOX COMPANY - 10/25/72

ATTENDANCE LIST

DUKE POWER COMPANY

K. S. Canady

BABCOCK & WILCOX

B. A. Karrasch
E. O. Hooker
G. E. Kulynych
A. H. Lazar
R. R. Steinke
R. N. Edwards
R. S. Baker
H. J. Fortune
G. D. Lindstrom

AEC

I. A. Peltier
J. ᵘ. Sniezek
C. hou
D. Lange
A. Schwencer
K. Wichman
K. Economos
V. Potapovs

TOPICAL REPORT
BAW-10037
REVISION 1
VESSEL MODEL FLOW TESTS

1. QUESTION: Verify the possible omission of the flow area term in equation 1-1.

RESPONSE: Equation 1-1 in B&W Report BAW-10037, Revision 1, is correct. The meter flow coefficient, k, includes the individual meter flow area as well as the constants required to make the Flow Factor a dimensionless variable

2. QUESTION: The flow frequency content and the related energy distribution was not determined by the measurements during the one-sixth scale model testing. Identify the contribution of this model testing to the postulation of forcing functions for response prediction analysis. Provide the bases for the use of the simple equation set forth on page 3-4 of BAW-10051 to compute the shedding frequency, since this method is valid only for a simple flow condition.

RESPONSE: A study of available literature and discussions with our consultants indicated that the flow frequency and energy distributions determined from the 1/6 scale model could not be correlated to actual vessel conditions. Further, since the structural characteristics of the reactor internals components were not simulated in the model, measurements of model structural response were not attempted.

Data from the 1/6 scale model was used to predict the velocity and static pressure distributions within the vessel and internals. This data was then used as the basis for the forcing functions described in BAW-10051.

The use of the simple equation to determine vortex shedding is only a part of the structural analysis of the internals components. The <u>total</u> analytical approach is conservative.

TOPICAL REPORT
BAW-10050
EVALUATION OF OCONEE
REACTOR COMPONENT FAILURE

1. QUESTION: As stated in page 4-12, the first mode frequency of the instrument guide tube is 250 Hz while the vortex shedding frequency is approximately 385 Hz, therefore, the first mode response may be excluded as a failure mode. However, higher modes may be in the range of the vortex shedding frequency or other forcing frequencies.

(a) Provide a comparison of the higher mode guide tube frequencies with the shedding frequency.

RESPONSE: The second mode of the instrument guide tube would be $\simeq$ 1000 Hz. This is substantially above the vortex frequency of 385 Hz. This would also be an unsymetric mode and would not be excited as easily . On page 4-11 of BAW-10050 in paragraph 4.4.3 it was stated the velocity could be as high as 60 fps. A velocity of 39 fps would give vortex shedding frequency of 250 Hz. With less than 4 pump operation the velocity would be less than 60 fps and could therefore excite the instrument guide tube at it fundamental frequency of 250 Hz. B&W still believes that vortex shedding was a contributing factor leading to the failure of the tubes.

(b) Provide the criteria that was used for the redesign of the instrument guide tubes.

RESPONSE: Instrument guide tubes will not be installed in the Oconee Reactors, therefore, no criteria for redesign are presented.

(c) Provide a discussion of other possible causes of failure, such as the mentioned random excitation of turbulence and the reactor coolant pump excitation. Include the effect of the pump shaft frequency of 20 Hz (Page 4-9).

RESPONSE: The pump shaft frequency of 20 Hz is not believed to be a major contributer to the excitation of the instrument guide tubes. The second blade passing frequency of the pump of 280 Hz also mentioned on Page 4-9 is sufficiently close to the naturally frequency of the tube (250 Hz) to have excited the tube at its natural frequency. There was also a 190 Hz frequency identified in the hot functional test data, which could have also caused excitation.

2. QUESTION: Provide a discussion on the following possible failure mode on the core instrument nozzels: The core structure vibratory motion and the cross flow loading may produce a rotational vibration mode in the guide tubes and associated lateral defromation of the lower tips. The lateral motion may produce vibratory contact with the inserted tip of the incore instrument nozzle and result in cyclic bending stresses at the bottom of the nozzle to failure.

RESPONSE: An investigation was conducted to determine whether mechanical coupling of the incore instrument nozzles with the guide tube assemblies could have caused or contributed to the failures. The interior of the incore instrument guide tube extensions were examined to determine if failure of an incore nozzle had occured without signs of contact between the nozzle and the guide tube. Evidence of contact occured in most cases. However, in four cases little or no contact was indicated. This substantiated the conclusion that the incore instrument nozzles could fail without excitation by the reactor internals.

TOPICAL REPORT
BAW-10051
DESIGN OF REACTOR INTERNALS
AND INCORE INSTRUMENT NOZZLES
FOR FLOW INDUCED VIBRATION

1. QUESTION: Describe the loading combinations and the analytical methods used to confirm the structural integrity of the instrumentation guide tubes. Provide the basis for the criteria that redesign is not necessary if two guide tubes fail during hot functional testing.

RESPONSE: Instrument guide tubes will only be installed on two B&W Reactors. For these reactors, a redesign of the instrument guide tubes will be presented in the respective FSAR's.

2. QUESTION: As shown in table 3-3 (page 3-26) the cantilever part of the guide tube and the flow distributor assembly (vertical) have approximately the same first mode frequencies. The configuration shown in figure 3-3 indicates that the vertical motion of the flow distributor may produce rotation and therefore lateral motion of the lower tip of the guide tube. Provide a summary of the dynamic analyses used to account for possible dynamic coupling of the guide tube and the flow distributor assembly. Include the effects of cross flow on the cantilever portion of the guide tube. The associated cyclic bending stresses at the incore instrument nozzle should also be provided.

RESPONSE: It is true that rotations as a result of vertical motion of the flow distributor will occur at the attachment points of the cantilevered portions of the guide tubes and the flow distributor. This was recognized as a potential source of lateral excitation on the guide tubes and was investigated as a part of the analysis. The results indicated, however, that these rotations would be quite small ($\approx 10^{-5}$ rad.) and the resulting lateral guide tube loadings would be considerably less than the conservatively assumed cross-flow loadings. In light of the above, this source of excitation was assumed to be included in the cross-flow loadings.

The results of any dynamic interaction between guide tubes and flow distributor will be measured during the hot functional testing. These results, conrrelated with the results of the in-air testing of an identical set of internals, will identify the amount of dynamic coupling.

3. QUESTION: The shedding frequency used for computing the β value of the drag force acting on the incore instrument nozzle was actually based upon a 2 inch diameter (page 3-5) of the lower portion. Since the upper portion is a 1-1/8 inch diameter (β=1), provide a summary of the analysis to show that excessive response amplitudes of the instrument nozzle will not occur.

RESPONSE: This possible effect was fully evaluated during the original design effort. The question correctly points out that resonance will apparently occur due to vortex shedding from the reduced diameter of the upper portion of the nozzle, with the assumed flow conditions. This is indicated by the frequency ratio $\beta = \omega_s/\omega_n = 1$ for the fluctuating component of the drag force. This is simply an anomaly arising from the accumulation of worst case assumptions and is not representative of the actual conditions. These assumptions included:

a. A cross-flow past the nozzle is assumed to be uniform over the entire length. Actually, the reduced diameter portion is inside the lower end of the guide tube and the cross-flow past it is considerably reduced.

b. The velocity past the entire nozzle was assumed to be 40 ft/sec. Actually, this value represents the conservative upper bound of the peak velocity at any point in the lower head of the vessel. Also, this velocity was assumed to be cross-flow (at right angles to the nozzle) rather than acting at a skewed angle which is the real case.

c. The Strouhal number "S" was assumed to be 0.45 which represents the upper bound of possible values. This parameter is actually a strong function of Reynolds number and hence, is dependent on the velocity and the diameter of the tube.

d. The natural frequency of the nozzle used in the calculations of β was 425 Hz. A more detailed analysis indicates that the actual frequency of the nozzle will probably be 550-600 Hz.

All these factors are combined to eliminate the possibility of resonance between the forcing functions and the structure.

4. QUESTION: Provide the basis for assuming that the lowest mode deflection of the thermal shield is 0.06 inches.

5. QUESTION: Provide the basis for assuming that the amplitude of other predominate modes of the thermal shield are a function of the ratio of the frequencies squared to the first mode (page 3-14).

6. QUESTION: Provide tha basis for neglecting the combined modal contribution effects in predicting the maximum radial deflection of the thermal shield under the hot functional testing and normal operational loadings (Table 3-5).

RESPONSE: Questions 4, 5 and 6 all deal with the thermal shield and the assumptions used in predicting its response, and will therefore be answered by a single ~~response~~. Reply.

Evaluation of the measured response data from the first Oconee Hot Functional Test indicated that the maximum amplitude of vibratory motion of the Thermal Shield was about .006" (before wear of the supports led to subsequent damage). To account for the possibility that we may not have measured amplitude at the peak location or time, a safety factor of 10 was placed on this measured value to establish a criteria for redesign. The resulting .060" amplitude was assumed to occur in the most probable (lowest) mode of operation of the thermal shield. To evaluate the effect of response in other modes, the stresses in the supports were determined for comparable amplitudes, using the ratio of frequency squared. This corresponds to an assumption of constant input force or acceleration. We expect the total amplitude to be considerably less than .060", so the results were not combined for the various modes. This assumption of amplitude is conservative in comparison to that measured for other operating reactors.

The revisions for the support design for the thermal shield increased its stiffness and greatly increased the strength of the support. In addition, removal of the vertical legs of the flow baffles reduced the peak annulus velocity and the forcing functions acting on the shield. Both of these changes are in the direction of further reduction of thermal shield motion.