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SUBJECT: Provides status of actions re IE Bulletin 88-002, "Rapidly Propagating Fatigue Cracks in Steam Generator Tubes."

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May 2, 1988

U. S. Nuclear Regulatory Commission
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Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Response to NRC Bulletin No. 88-02: Rapidly Propagating Fatigue Cracks in Steam Generator Tubes

References: 1) NRC Bulletin No. 88-02, "Rapidly Propagating Fatigue Cracks in Steam Generator Tubes", dated February 5, 1988.

2) Letter from Mr. D. C. Hintz (WPSC) to Mr. A. B. Davis (NRC), dated April 4, 1988.

3) Letter from Mr. D. C. Hintz (WPSC) to Mr. A. B. Davis (NRC), dated April 13, 1988.

The attachment to this letter provides the status of our actions relative to NRC Bulletin 88-02. Per agreement with our NRC Project Manager, this submittal provides the results of our actions taken under item A of the bulletin and provides the status of the actions we are taking under item C.2. Our actions relative to an enhanced primary-to-secondary leak rate monitoring program, required by item C.1 of the bulletin, have previously been provided in letters dated April 4, 1988 and April 13, 1988 (references 2 and 3).



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If you have any questions concerning this issue, please contact me or a member of my staff.

Sincerely,

D. C. Hintz
Vice President - Nuclear Power

JPG/mjm

Attach.

cc - Mr. Robert L. Nelson, US NRC
Mr. A. B. Davis - US NRC, Region III

Subscribed and Sworn to
Before Me This 2nd Day
of May 1988

Jeanne M. Stein
Notary Public, State of Wisconsin

My Commission Expires:

June 23, 1991

Attachment I

Letter From D. C. Hintz (WPSC) To Document Control Desk

Dated

May 2, 1988

Response to NRC Bulletin No. 88-02:

Rapidly Propagating Fatigue Cracks in Steam Generator Tubes

Response to NRC Bulletin No. 88-02:
"Rapidly Propagating Fatigue Cracks in Steam Generator Tubes"

NRC Bulletin 88-02 requested that plants with Westinghouse designed steam generators having carbon steel tube support plates implement actions to minimize the potential for a steam generator tube rupture such as occurred at North Anna Unit 1 on July 15, 1987. This tube rupture event was caused by a rapidly propagating fatigue crack at the top cold leg tube support plate.

The cause of the North Anna Unit 1 tube rupture was determined to have been high cycle fatigue. Fluidelastic excitation was concluded to be the source of the alternating stresses which induced the fatigue. Analysis has shown that for this type of failure to occur, all of the following must be present:

- denting at the top tube support plate,

- a fluidelastic stability ratio approaching that of the ruptured North Anna tube, and

- the absence of effective antivibration bar (AVB) support.

Item A of the bulletin requests licensees to review the most recent steam generator tube inspection data for evidence of denting at the top tube support plates. The definition of denting includes the evidence of support plate corrosion with the presence of magnetite in the tube-to-tube support plate crevice regardless of whether actual tube deformation is present.

Wisconsin Public Service Corporation (WPSC) contracted Westinghouse to perform a review of our 1986 eddy current inspection data. The 1986 inspection data was used because that inspection included essentially the full length examination of 100 percent of the accessible tubes. The data review was done for all tubes in rows 8 through 12. Westinghouse has determined that these rows are potentially susceptible to the North Anna failure mechanism. The analysis was done to identify the presence of AVBs by row, and also to identify tube deformation due to denting, indications of tube support plate corrosion, and any indications of tube wear which may indicate tube vibration.

The results of this data analysis indicated that only a small fraction (less than 1 percent) of the tubes reviewed were physically deformed based on a 3 volt dent criteria. It was observed however, that a high percentage of the eddy current signals for the top tube support plate tube holes indicate tube support plate corrosion. This second condition meets the NRC definition of denting as stated in the bulletin. No tube wall thinning was reported at the AVB/tube intersections in the row 8 through 12 tubes reviewed. This lack of wear indications is viewed as contributory evidence that the tubes in this region are not fluidelastically unstable.

During the eddy current data review, the insertion depths of the lower set of AVBs were established. This information was used to determine which tubes are or are not effectively supported by AVBs. In future analysis, this data will be used in an assessment of flow peaking factors for tubes found to be unsupported and potentially susceptible to the North Anna failure mechanism.

For the most part, AVB insertion depths were determined from direct observation of the eddy current data. Direct location of the AVBs is done by counting the number of characteristic signals indicating the intersection of an AVB with the tube. The presence of two (2) of these signals assures that the tube is supported by at least one (1) AVB at the tube centerline. The presence of one (1) AVB signal is not sufficient to assure tube support since the position of the AVB centerline relative to the tube centerline cannot be determined. The location and length of single intersection signals is recorded since it can be of use in interpreting other AVB location data.

In cases where direct correlation of the eddy current data was not possible, AVB insertion depths were determined by projection of the AVB apex tangent point. This is done using data from tubes in higher rows of the same column. Projection is necessary in cases where eddy current data is noisy, where data is unavailable due to tube plugging, or where data is inconsistent or ambiguous. Insertion depth projections are based on determinations of the distance from the top tube support plate centerline to the centerline of each AVB. The projections are derived from correlations developed for the tube and AVB geometry of each Westinghouse steam generator model. The use of data for multiple tubes in a given column provides a consistency check of the projected insertion depth. Past Westinghouse experience shows that the projected positions tend to be conservative so the actual AVB position is further inserted than the projected position.

The results of the AVB insertion depth determinations for the Kewaunee steam generators are shown on the AVB maps attached as Figures 1 and 2. For Steam Generator 1A, AVB positions were established from direct observation of visible AVB/tube intersection signals for all columns except 6, 35, 39, 63, and 79. For these columns, the projection method was used to determine AVB insertion depths. For Steam Generator 1B, the projection method was required for columns 34, 35, 49, and 62. 1986 eddy current data was available for all of the tubes indicated on the maps as plugged except for Steam Generator 1B, row I1 column 48. All of the other tubes indicated as plugged were removed from service after the 1986 inspection.

For those tubes where the projection method was used, the projected insertion depth is shown on the AVB maps. The reference features for the projection value are the centerlines of the tube and the AVB. For a tube in a given row (N) to be considered supported, the AVB projection value must be equal to or less than N.1. The decimal portion of this value indicates the fraction of the tube pitch above the tube centerline to which the AVB is inserted. For example, a projection value of 9.1 indicates that the centerline of the apex of the AVB penetrates to 0.1 x the tube pitch above the centerline of the row 9 tube. In this example, the row 9 tube in this column would be at the limit of what is considered to be supported.

A summary of the row 8 through 12 tubes found to be unsupported in each steam generator is shown in Table 1. Westinghouse performed further review of these tubes to identify which, if any, may be susceptible to fluid induced tube vibration. Since row 8 tubes are generally not in the critical range for model 51 steam generators such as those at Kewaunee, no further review of these tubes was done. In Steam Generator 1A, the only row 9 through 11 tubes found to be

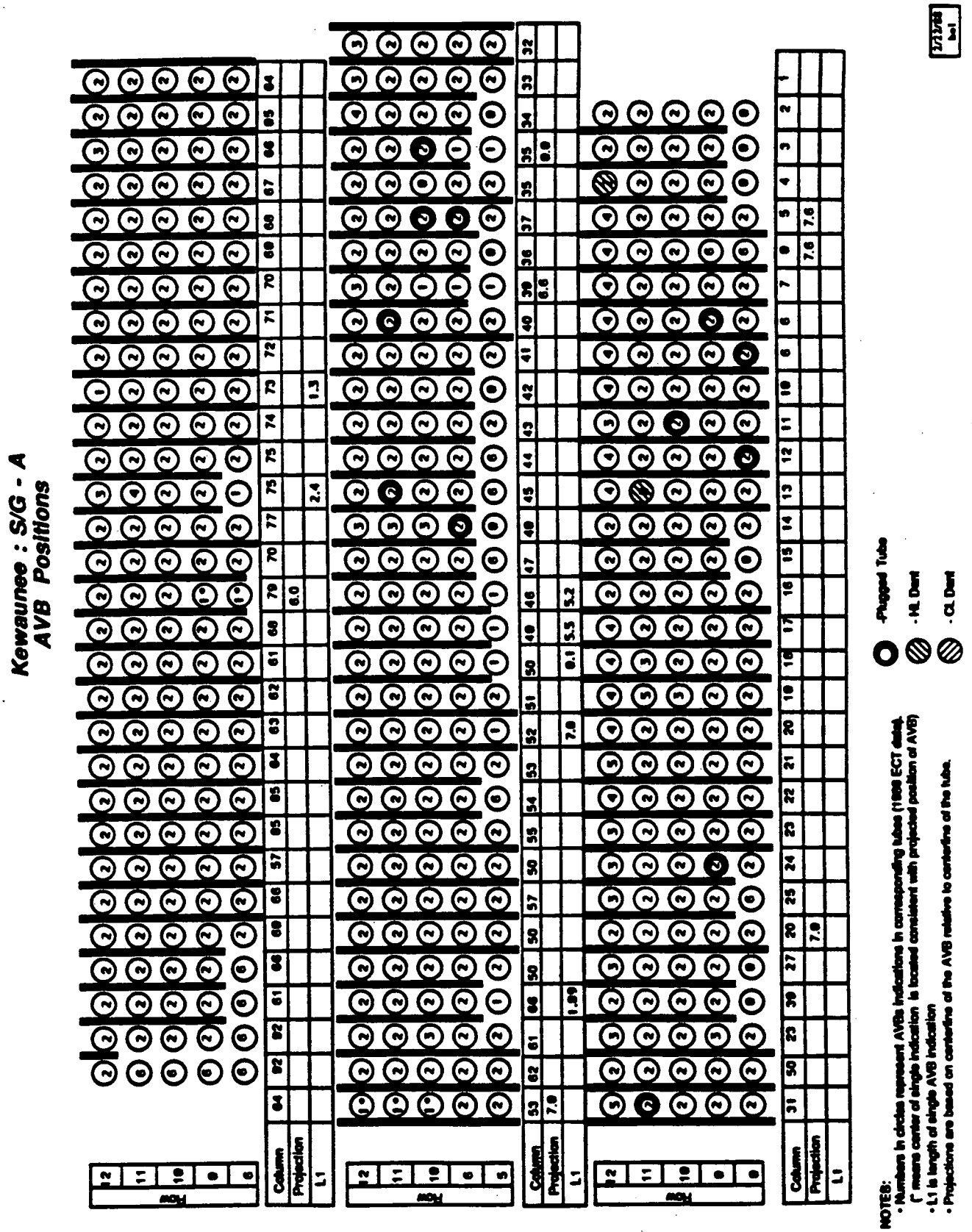
unsupported were in the outside column, column 93. These three (3) tubes were identified as requiring further analysis. In Steam Generator 1B, the row 9 tubes in columns 35, 42 through 54, and 60 through 63 were found to be unsupported. Westinghouse stated that based on their prior experience with model 51 steam generators, row 9 tubes are susceptible to this failure mechanism only under extreme flow peaking conditions. Based on this experience, the row 9 tubes in columns 42 through 54 and 60 through 63 were found not to require further flow and fatigue analysis. The row 9 column 35 tube, however, was found to be located in an AVB pattern which could result in elevated flow peaking factors. This tube was identified for further detailed evaluations of flow peaking and fatigue usage factors. All row 10 tubes in this steam generator were found to be supported, but the row 10 column 49 tube marginally satisfied the support criteria of the projection method. This tube also lies in an AVB pattern which generally leads to high flow peaking factors. For these reasons, this tube was identified for further evaluation despite the marginally acceptable support conditions. All row 11 tubes in Steam Generator 1B and all row 12 tubes in both steam generators were found to be supported.

All five (5) of the tubes identified above as requiring further analysis exhibited corrosion at the top tube support plate, and thus meet the bulletin definition of dented. Further analysis is being done under the general assumption that these tubes are clamped at the top tube support plate and may thus be susceptible to flow induced vibration.

WPSC is contracting Westinghouse to perform the necessary analysis of these five (5) tubes in accordance with the Westinghouse recommended approach. This approach includes the determination of critical velocities for fluidelastic instability from wind tunnel tests using our AVB configurations. Flow peaking factors will then be determined as a ratio of critical velocities between our AVB configurations and other configurations including that for the North Anna row 9 column 51 tube. In addition, flow calculations will be done to determine Kewaunee specific full load flow conditions. These calculations will be used to determine the fluidelastic stability ratios. Based on the results of the above analysis for the Kewaunee tubes and results of detailed analysis done for other plants, an engineering assessment will be made regarding the susceptibility of the five (5) tubes to the tube fatigue failure mechanism.

Following the completion of this analysis, WPSC will determine the need for further action. If one or more of the tubes is found to be susceptible, we will evaluate the possible actions which would include more detailed analysis or removal of the affected tube(s) from service.

In summary, WPSC has performed the eddy current data review required by NRC Bulletin No. 88-02, item A and has completed the assessment of the depths of penetration of the antivibration bars as discussed in item C.2. In addition, we have implemented an enhanced primary-to-secondary leak rate monitoring program as required by item C.1. We are conducting the further analysis required by item C.2 and expect to submit the results of this analysis on June 30, 1988. This schedule has been previously discussed with our NRC Project Manager.


Kewaunee : S/G - A
AVB Positions
Column
Projection
L1
Row
NOTES:
• Numbers in circles represent AVBs indications in corresponding tubes (1988 ECT data).
(* means center of single indication is located consistent with projected position of AVB)
• L1 is length of single AVB indication
• Projections are based on centerline of the AVB relative to centerline of the tube.
- Plugged Tube
- Ht. Dent
- Ct. Dent

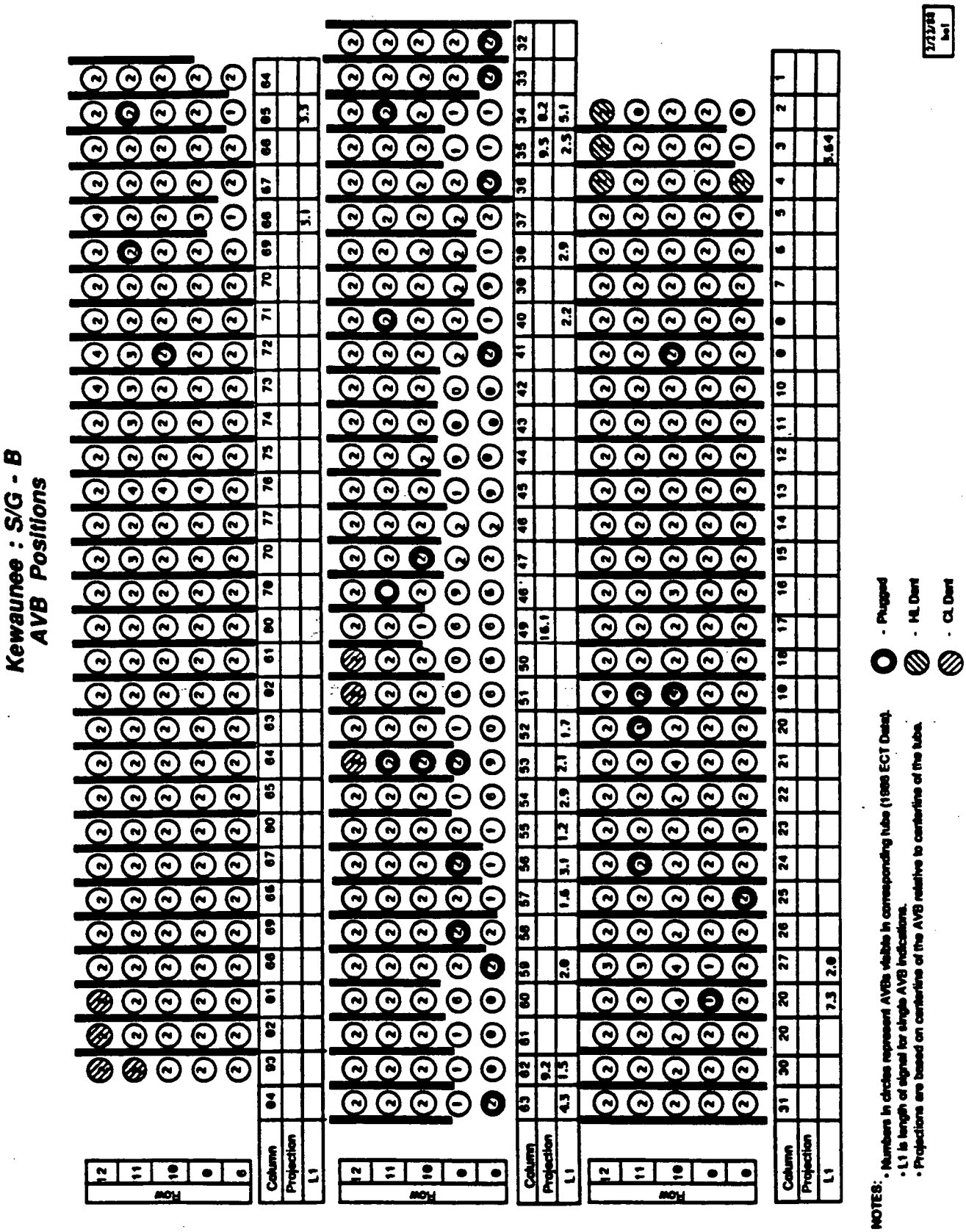

Kewaunee : S/G - B
AVB Positions
Row
Column
Projection
L1
NOTES:
• Numbers in circles represent AVBs visible in corresponding tube (1988 EOT Data).
• L1 is length of signal for single AVB indications.
• Projections are based on centerline of the AVB relative to centerline of the tube.
- Plugged
- HL Dent
- CL Dent

Table 1

Kewaunee Nuclear Power Plant

Steam Generator 1A and 1B Unsupported Tube Summary

| Steam Generator | Row | Columns |
|---|---|---|
| 1A | 8 | 2, 3, 4, 15, 25, 28, 34, 35, 38, 39, 42-50, 54, 60, 76, 90-93 |
| | 9 | 93* |
| | 10 | 93* |
| | 11 | 93* |
| | 12 | None |
| 1B | 8 | 2, 3, 34, 35, 38-56, 60-63, 68 |
| | 9 | 35*, 42-54, 60-63 |
| | 10 | 49* |
| | 11 | None |
| | 12 | None |

* Tubes identified by Westinghouse as requiring further analysis for susceptibility to flow induced vibration.