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Westinghouse Energy Systems

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REEVALUATION OF U-BEND TUBE FATIGUE FOR THE KEWAUNEE PLANT STEAM GENERATORS

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PREPARED FOR WISCONSIN PUBLIC SERVICE CORPORATION

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FOREWORD

Introduction

The initial assessment for Kewaunee steam generator small radius tube fatigue was performed in late 1987 and early 1988 (Reference 1). The Kewaunee assessment was reviewed in light of more recent test results in early 1989 (Reference 2). In neither of the assessments were any tubes identified as requiring modification or corrective action.

The NRC has requested that Westinghouse reevaluate the Anti Vibration Bar, (AVB) positions and associated flow peaking factors for a number of early steam generators evaluations. This reevaluation is intended to take advantage of improvements in the methods for defining AVB positions and the larger flow peaking data base which has been built up since 1988. Kewaunee is included in this set since the initial evaluation was performed in late 1987 and early 1988.

AVB Position Mapping

The AVB positions found in the Kewaunee steam generators in the first analysis (Reference 1) are relatively favorable. All interior tubes in rows 11 and higher were found to be supported. Only one interior tube in row 10 was possibly unsupported. There were eighteen interior row 9 tubes which may have been unsupported.

In Reference 2, the case of the unsupported row 8 tubes were considered and the assessment was made that the length of the AVBs installed in columns 12 through 84 is not great enough for the bars to be connected to the retainer ring if the AVB is inserted beyond the bottom of row 7. Therefore, only AVB configurations in which AVBs penetrate one row beyond the subject tube need be considered when searching to find the maximum flow peaking factor for a row 8 tube. The configuration with this restriction which has the highest flow peaking factor is configuration 4c which has a flow peaking factor of [ ]^{a,c}. This corresponds to a peaking ratio of [ ]^{a,c}. From Figure 1 which is repeated from Reference 2 it can be noted that all tubes in row 8 have a maximum allowable peaking ratio of not less than [ ]^{a,c}. Hence any row 8 tube between columns 12 and 84 is acceptable whether or not it is supported.

It should be noted that Figure 1 presents the maximum allowable peaking ratio by tube position for the operating conditions listed below:

Steam Flow (per S/G)	3.53×10^6 lbm/hr
Steam Pressure	739 psia
Circulation Ratio	[ ]^{a,c}

From inspection of the ECT data and AVB position maps given in Reference 1 it was determined that the only region in either of the Kewaunee steam generators where tubes are potentially unsupported in rows 9 or 10 is from column 34 to column 64 in steam generator B. Therefore the reevaluation of the Kewaunee steam generator AVB maps was performed over the region of column 32 to column 71 in steam generator B. All the ECT data from rows 8 through 12 was used in the evaluation of AVB positions in the region.

Figure 2 shows the map of AVB positions in steam generator A and is repeated from Reference 1 for completeness. Figure 3 is the revised AVB map for steam generator B. The changes in the AVB map for steam generator B in going from Reference 1 to the present work are small but significant. The row 10 tube which was possibly unsupported (R10C49) has been shown to be unsupported but to have a configuration of adjacent bars which provides no flow peaking. One of the row 9 tubes (R9C35) which was originally shown to be unsupported and which could have had a high peaking with a small change in the AVB position has been shown to be supported. A row 8 tubes which was originally shown as unsupported with high flow peaking (R8C68) has been shown to be supported. From these maps the flow peaking factors for all unsupported tubes were determined. As noted above, for row 8 unsupported tubes, the adjacent tubes extending below row 8 are assumed to extend into row 7 to the position which produces the largest flow peaking factor.

Allowable and Actual Flow Peaking Ratios

The flow peaking factors, peaking ratios and maximum allowable peaking ratios for all unsupported tubes with flow peaking factors greater than one are given in Table 1. It should be noted that the peaking ratio is the flow peaking factor divided by the flow peaking factor for North Anna R9C51. The AVB insertion patterns and associated flow peaking factors and peaking ratios are shown in Figure 4. The maximum allowable peaking ratios are taken from Figure 1 and represent the peaking ratio which causes the stress ratio to be unity after operation over the design basis period. Inspection of Table 1 shows that there are no tubes in either Kewaunee steam generator where the peaking ratio is greater than [ ]^{a,c} of the maximum allowable peaking ratio.

Conclusions

All of the tubes in the Kewaunee steam generators are acceptable for operation over the full design basis period of the plant without any corrective action at the flow and pressure conditions given above. A change in operating conditions could lower the maximum allowable peaking ratio, however this ratio could be decreased by as much as [ ]^{a,c} for the most limitng tube before the actual peaking ratio would equal the maximum allowable peaking ratio.

Table 1
Velocity Peaking Factors and Peaking Ratios
for Kewaunee U-bend Flow

Steam Generator	Row No	Column No	Type of AVB Insertion	Peaking Factor	Peaking Ratio	Maximum Allowable Peaking Ratio
A	8	90	[			], a,c
		76				
		60				
		54				
		39				
		38				
		35, 34				
		28				
		25				
		15				
		4				
	All of the remaining					
B	8	35				
	9	60				
	All of the remaining		]			

References

1. Susceptibility to High Cycle Fatigue of Steam Generator Tubes - Kewaunee Nuclear Power Plant, STD-7.2.2.1-8217, June 27, 1988

2. Kewaunee Steam Generators - Review of Tube Fatigue Evaluation in Light of More Recent Test Results, WPS-89-116, February 14, 1989

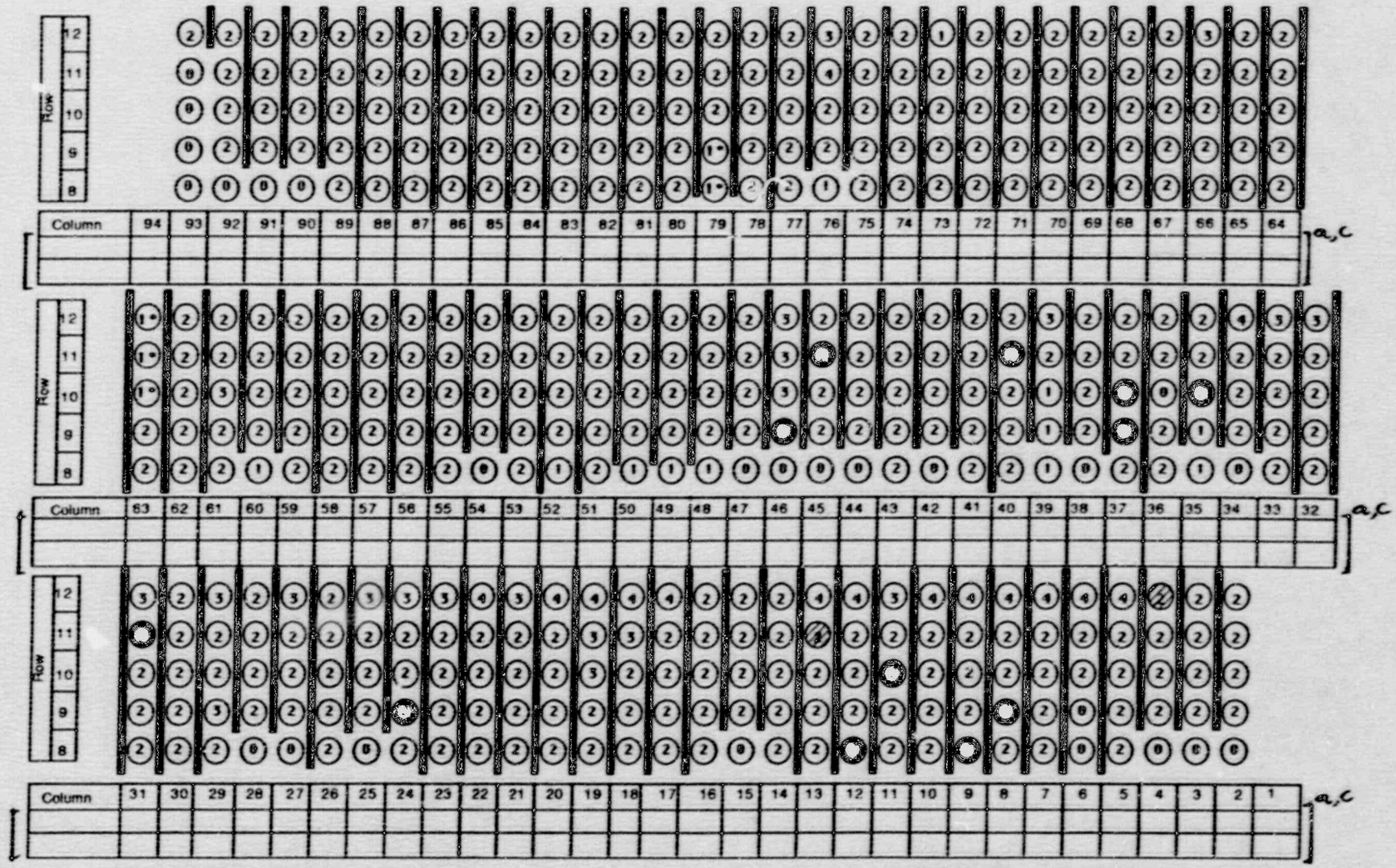
KEWAUNEE – MAX ALLOW REL FLOW PEAKING

(CASE J RESULTS)

[ ]a,c

Figure 1

Figure 2
Kewaunee : S/G - A
AVB Positions



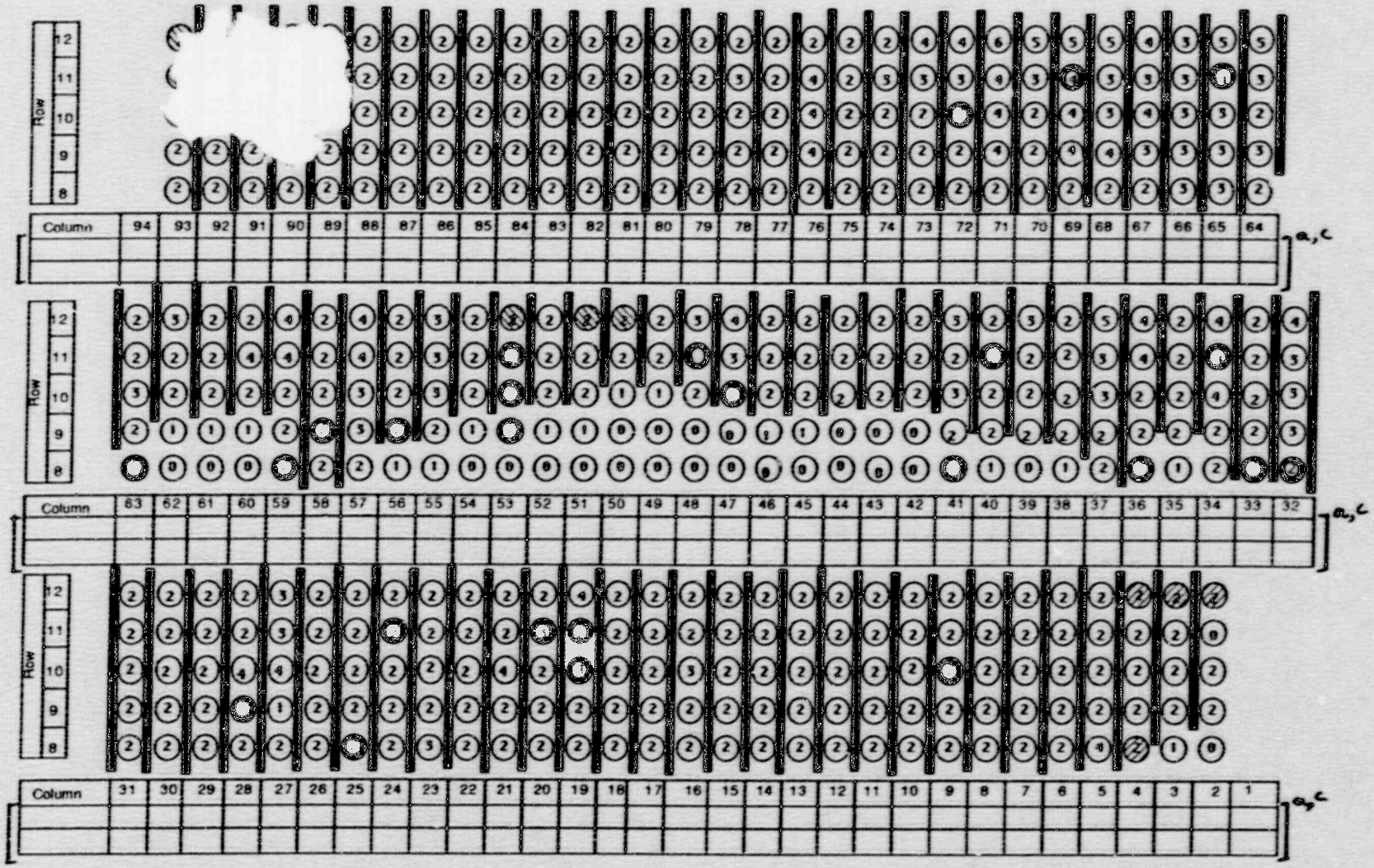
NOTES:

- Numbers in circles represent AVBs indications in corresponding tubes (1R28 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
- HL Dent
- CL Dent

2/22/Rd
fwl

Figure 3
Kewaunee : S/G - B
AVB Positions



NOTES:
- Numbers in circles represent AVBs visible in corresponding tube (1988 ECT 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

8/21/96
bwl/hjc

TYPE OF AVB INSERTION	PEAKING FACTOR	TYPE OF AVB INSERTION	PEAKING FACTOR
[	a,c	[	a,c

Final Peaking Factor for Kewaunee

Figure 4