

## Revised Performance Demonstration Program for Steam Generator Tubing Analysts

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### 1. Introduction

The performance demonstration program for steam generator tubing analysts in the nuclear power plant has been implemented by KEPRI(Korea Electric Power Research Institute) in accordance with the Notice 2008-23 of Ministry of Education, Science and Technology[1]. According to the Notice, non-destructive examination personnel who analyze eddy current data for steam generator tubing should be qualified as the QDA(Qualified Data Analyst). An individual who successfully completes the requirements described in the EPRI Pressurized Water Reactor Steam Generator Examination Guidelines, Appendix G is recognized as the QDA[2]. In the revision 7 of the EPRI Guideline, the QDA program was revised. The revised performance demonstration program for steam generator tubing analysts was reviewed in this paper. It is expected that the revised program will be applied for eddy current analyst in Korea in the near future.

### 2. QDA Program

According to the revised EPRI Guideline[2], an individual seeking qualification as a QDA shall be certified Level II or III in accordance with the employer's written practice in eddy current examination. To be considered eligible for the examinations, applicants shall have completed the training course which consists of a minimum of 40 hours including classroom and laboratory exercises. To be considered a QDA after the completion of training, an analyst shall successfully pass both written and practical examinations for all damage mechanisms available at the time of testing.

For each written examination administered as part of the qualification examination, it is recommended that a question bank containing at least twice the minimum number of questions be available. It is also recommended that each qualification examination be assembled from the question bank using a random sampling process. The written examination shall contain a minimum of forty questions covering the lecture material. A grade of at least 80% shall be required to pass the written examination.

It is recommended that the practical examination consist of eddy current data sets that are randomly selected and contain indications indicative of all damage mechanisms covering steam generator operating experience. Each damage mechanism is represented by a data set. The expert opinion is used to

establish eddy current truth for grading purposes. Damage mechanism categories to be included in the practical examination are thinning, support structure wear, outside diameter IGA/SCC, primary-side SCC and loose part wear. It is recommended that adequate numbers of flawed and unflawed grading units be used to meet the probability of detection (POD), statistical confidence level (CL), and false-call requirements of Table 1. It is recommended that the practical examination contain a minimum of 11 flawed grading units for each damage mechanism category where only detection is being applied. It is also recommended that the number of unflawed grading units selected for the practical examination be equal to at least twice the number of flawed grading units.

Table 1. Performance Demonstration Test Matrices for Flaw Detection and Sizing

Total No. of Flawed Units	Flaw Detection Acceptance Criteria for a Given Damage Mechanism Category				False Call Acceptance Criteria	
	No. of Flawed Grading Units		Minimum Acceptance Criteria for Detection		Minimum No. of Unflawed Grading Units	Maximum No. of False Calls
	<40% <*	≥ 40% ≥ *	<40% <*	≥ 40% ≥ *		
16	5	11	4	11	32	3
17	5	12	4	12	34	3
18	6	12	5	12	36	4
25	8	17	7	17	50	5
26	8	18	7	17	52	5
36	12	24	10	23	72	7
37	12	25	10	23	74	7
46	15	31	12	29	92	9
47	15	32	12	29	94	9

\* 80% POD, 90% CL applicable to the ≥ 40% TW data set.  
\* 80% POD, 90% CL applicable to the ≥ 1 volt with a voltage data set.  
\* 80% POD, 90% CL applicable to the ≥ 0.4 in. for axial length data set.  
\* 80% POD, 90% CL applicable to the ≥ 40° for circumferential length data set.

It is recommended that the practical examination contain a minimum of 16 flawed grading units for each damage mechanism category where both detection and sizing are being applied. The number of unflawed grading units selected for the practical examination shall be equal to at least twice the number of flawed grading units. It is recommended that for each practical examination data set, the individual be provided with a description of the examination techniques performed along with a set of analysis guidelines for each technique.

Practical examinations for each data set shall be graded by one or more of the following methods depending on the technique applicability of detection, sizing, and orientation. Personnel shall be considered

qualified for detection of a specific damage mechanism if all of the following requirements are met:

- A POD of at least 80%, at a 90% CL for flawed grading units  $\geq 40\%$  TW, length (axial)  $\geq 0.4$  in. (10.2 mm), length (circumferential)  $\geq 40^\circ$  or amplitude  $\geq 1.0$  volt.
- Detection of at least 80% of the flawed grading units  $< 40\%$  TW, length (axial)  $< 0.4$  in. (10.2 mm), length (circumferential)  $< 40^\circ$  or amplitude  $\geq 0.5$  and  $< 1.0$  volt.
- The number of reported false calls is no more than 10% of the total number of unflawed grading units.

Personnel shall be considered qualified for performing sizing measurements on a specific damage mechanism if a root mean square error (RMSE) of less than or equal to 10% is demonstrated. The sample set, RMSE, is calculated using the following equation:

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (M_i - T_i)^2} \quad (1)$$

where  $M_i$  is the eddy current measured flaw parameter assigned by the individual analyst for the  $i$ th indication,  $T_i$  is the eddy current measured flaw parameter for the  $i$ th indication determined by expert opinion, and  $n$  is the number of measured grading units in the data set. Personnel shall be considered qualified for determining orientation of a specific damage mechanism if the correct orientation is reported on at least 80% of the flawed grading units.

The performance demonstration program for the steam generator tubing analysts in Korea was officially commenced on July 1, 2004. The total 145 candidates have been applied for the QDA test by the end of 2008. As shown in Figure 1 through 5, ninety nine percent of applicants have passed in the written examination. Eighty six percent of examinees have passed in the practical examination, 55% in the first trial, 22% in the second and 9% in the final. Pitting and thinning are the dominant degradation mechanisms which Korean analysts have failed to detect in the QDA. Among the acceptance criteria, the detection is the critical factor to pass in the practical examination to the Korean examinees.

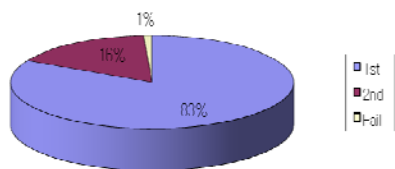


Figure 1. Results for Written Examination

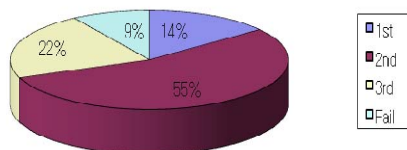


Figure 2. Results for Practical Examination

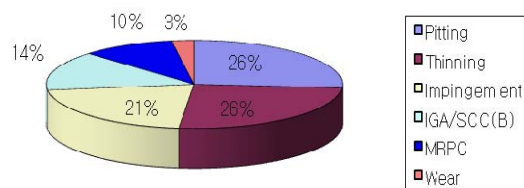


Figure 3. Results for Fail in DM of Bobbin Data

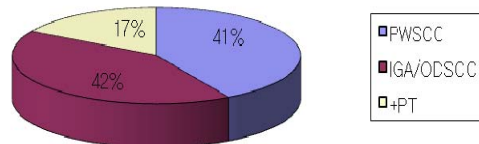


Figure 4. Results for Fail in DM of MRPC Data

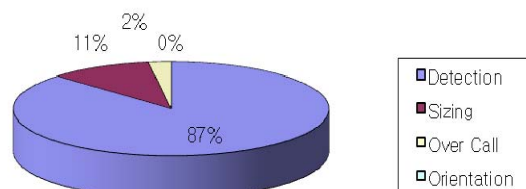


Figure 5. Results for Fail in Acceptance Criteria

### 3. Conclusion

A single missed or incorrectly classified defect indication in eddy current data of steam generator tubing can lead to a plant shutdown or a tube rupture event. To reduce the possibility of such consequences, the analyst's performance should be thoroughly demonstrated. The QDA program has been implemented since 2004 in accordance with the EPRI PWR Steam Generator Examination Guidelines, Appendix G. The results show that pitting and thinning are the dominant degradation mechanisms which Korean analysts have failed to detect in the QDA test. EPRI revised the QDA program in the Guideline Revision 7. The revised one will be introduced in Korea in the near future.

### REFERENCES

- [1] Ministry of Education, Science & Technology, Notice 2008-23, The Regulation on In-Service Inspection of Nuclear Facilities, 2008.
- [2] Electric Power Research Institute, Pressurized Water Reactor Steam Generator Examination Guidelines: Revision 7, Appendix G, 2007.