Risk Based Strategies for Inspection and Maintenance of Nuclear Power Plants
(3) Maintenance management based on reliability evaluation in consideration of responding capability against failure modes

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The authors have started developing the reliability evaluation method for the maintenance management programs focused on the capabilities to deal with the deviation of the management criteria after the occurrence of the failure modes on the components of the NPPs. And it was tried to examine the possibility of a quantitative evaluation approach on the maintenance management by quantitatively setting the score values of the FMEA method.

Keywords: maintenance management, reliability evaluation, risk priority, FMEA, IGSCC

1. Introduction

The quantitative evaluation approach on the effects of three capabilities to deal with the deviation of the management criteria on the failure mode was considered. And the three capabilities of Capability-A, Capability-B and Capability-C were associated with the probability (P), the detectability (D) and the severity (S) of the FMEA (Failure Mode and Effect Analysis) method. In addition, the trial analysis on a butt weld line of 600A PLR (Primary Loop of Recirculation system) piping degraded by the IGSCC was conducted to verify the usefulness of the evaluation approach. And it was discussed on the future works for the improvement of this approach as well.

2. Trial analysis on the butt weld line on PLR piping degraded by the IGSCC

2-1. Definition of the three capabilities respect to the maintenance management

The following three capabilities were defined as the probability (P), the detectability (D) and the severity (S) of the FMEA method related to the maintenance management to keep the normal operating plan of the NPP:

Capability-A: It was defined as the capability to predict the possibility of the deviation of the management criteria (crack depth within 25% of piping thickness) of the IGSCC. The crack depth at the 5th year test of the crack growth analysis was used for the input condition of the probability (P). And the crack growth analysis results of the weld lines welded by the HSW (Heat-Sink Welding) and the in-gas welding were utilized.

Capability-B: It was defined as the capability to detect the IGSCC exceeding the management criteria of a weld line of the PLR 600A piping. The RMSE (Root Mean Square Error) as the precision of crack detection was used for the input condition of the detectability (D). And the results of RMSE on crack depths measured by the phased array probe and the longitudinal wave 45 degree angle beam probe was utilized.

Capability-C: It was defined as the capability to repair the piping from the deviation of the management criteria in the normal operating period of the NPP. The repairing period was used for the input condition of the severity (S). And the repairing periods repaired by the WOL (Weld Overlay) and the piping replacement were utilized.

3. Future works

There is plenty of room for improvement of the approach in future. The vectors represented by each capability are different, even if the results of the risk priority of FMEA method are the same value, they have completely different meanings. And it would be solved by considering indexes that could be independently evaluated for each capability.

Furthermore, it revealed that it made possible to finely set the score values of the capabilities by quantifying the score value, but on the other hand each score value had uncertainty. Therefore, it would be necessary to develop the describing of score values of the capabilities and the RPN including uncertainty in the future works.