A Comparison of the Monitoring Programs for Structures in NPPs

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1. Introduction

Korea Hydro & Nuclear Power Co. (KHNP) is developing a Maintenance Rule (MR) implementation program which monitors the maintenance effectiveness of NPPs. At this time, the standardized MR implementation programs were developed for Optimized Power Reactor 1000MWe (OPR1000) and Westinghouse 900MWe (WH900) type NPPs and are being implemented at each plant.

Although the MR guidelines recommend structures to be included in the scope of the MR program, structure monitoring is excluded from the standard MR programs in KHNP for the following reasons:

a. The performance monitoring for structures using the MR program is considered not to be effective monitoring tool because aging of structures can be monitored over a long period of time (5~10 years).

b. The monitoring of structures has been accomplished using Periodic Safety Review (PSR) in KHNP.

In this paper, we will present a review and comparison of three programs for structure monitoring. They are current structure monitoring procedures in KHNP, the PSR program, and the Byron NPP's structure monitoring based on the MR.

These three approaches will be discussed from the point of whether the structure monitoring using the MR program would be necessary on top of the PSR and structure monitoring procedures currently used at the plant sites.

2. Review of structural performance monitoring by the current programs in KHNP

In this section, the existing performance monitoring and evaluation programs used in the KHNP plants for structures will be reviewed in relation with the MR concept.

2.1 Review of structural procedures

Procedures for safety related concrete structures, steel structures, and protective coating aging inspection are provided and put in practice at each plant. The application of aging inspection procedure for safety related concrete structures is limited to safety related buildings specified in FSAR chapter 3.2. This procedure requires a routine inspection (half-year period), a regular inspection (5 year period) and special inspection based on inspection items and depth. The inspection items for concrete structures consist of several elements which can identify concrete integrity (e.g., spalling cracking, delaminations, water in-leakage, chemical leaching and peeling paint, etc.). This procedure classifies the condition of structures according to the acceptance criteria for each inspection as follows: acceptable, acceptable with requiring periodic monitoring, acceptable with requiring corrective action, and unacceptable [4]. If any inspection element is evaluated as 'acceptable with requiring corrective action', it is required to examine the effectiveness of maintenance at least annually. This concept is similar to the intensive monitoring of the MR program.

The results of structural inspection are linked to the Structure Lifetime Monitoring System (SLMS) program which systematically manages the integrity of structures through quantitative evaluation. Structural performance is evaluated by analyzing input data, and comparing them to the previous data. And then, an appropriate maintenance plan is set up based on the evaluation results.

2.2 Review of the PSR program

The structural aging state is examined every 10 year and suitability of structural aging program is evaluated by the PSR program in KHNP. If the result of evaluation shows that the integrity of structure has a problem, safety enhancement should be made and corrective action needs to be taken systematically according to the related regulations.

The requirements and applications of the structural PSR are similar to those of the MR program. Test and inspection results, and maintenance history during 10 years are analyzed and evaluated to identify that the structures are within the design base acceptance criteria and trend of performance [5]. Because PSR is not a part of regulation in the U.S., structures are monitored by the MR program. In Korea, however, the performance of structures is evaluated by the PSR program.

3. Methodology to apply the MR program for structure monitoring

In this section, the method suggested in NUMARC 93-01 and the Byron NPP's case are discussed.

3.1 Review of the MR program concept

According to NUMARC 93-01, the scope of the monitoring program shall include safety and non-safety related Structures, Systems, and Components (SSCs). Also structures should be monitored using performance criteria by the MR program [1].

SSCs could be classified largely as active components, passive components, and structures.

The MR program is basically to monitor active component. In other words, the MR program is to minimize functional failure (FF) and optimize out of service time (OOST) to maintain design functions. Herein, FF and OOST are applied to active components.

The Condition Monitoring Criteria (CMC) can be applied for functions which are difficult to apply FF and OOST. Also it can be used to complement FF criteria called Reliability Performance Criteria (RPC).

Condition monitoring should be predictive in nature and provide early warning of degradation so as to prevent SSCs from reaching a functional failure state through preventive actions. The CMC methodology can be applied not only to active components such as electrical breakers, cards and relays of I&C but also to passive components such as structures and piping lines.

3.2 Review of the structure monitoring in Byron NPPs

Byron NPPs selected structures within the scope of the MR program according to NUMARC 93-01. All monitored structures were combined into one performance criteria. At the early stage, Byron NPPs developed only Reliability Performance Criteria (RPC) defined as equal to or less than 1 functional failure per 2 years for each segment of structures. Later the CMC was added to the performance criteria, which was equal to or less than 6 events per 2 years per unit. Also, the structural procedure was revised to implement the condition monitoring.

The structure monitoring criteria in Byron NPPs are summarized in Table 1. The judgment on the condition of structure is made based on whether it is a functional failure or performance degradation. The criteria in Table 1 are similar to one used in KHNP. According to Table 1, the performance degradation is considered as a violation of CMC [2, 3].

At the early stage of developing the MR program, Byron NPPs treated structures as inherently reliable and, therefore, did not include them in the MR program. Through the pilot inspection, however, the USNRC suggested the utilities to consider monitoring structures [2]. Later, monitoring structures was included in the MR scope as a regulatory requirement.

Table 1 Judgment criteria for structure monitoring

Judgment criteria	Functional Failure	Performance degradation
Acceptable	No	No
Acceptable with deficiencies	No	No
Acceptable with requiring corrective action	No	Yes
Unacceptable	Yes	-

3.3 Methodology to establish performance criteria for structures

Structural performance criteria could be established by using the methodology of condition monitoring criteria applied to NSSS or BOP systems or by adapting structural performance criteria of Byron NPPs. The CMC will be more suitable than RPC when structures' degradation is monitored. The judgment criterion of "acceptable with requiring corrective action" in Table 1 means a violation of CMC that requires intensive monitoring.

4. Conclusion

For structural performance monitoring, current plant procedures were studied and the PSR program was reviewed. And also the structural MR performance criteria of Byron NPPs were reviewed.

Through the comparison of the PSR and current practices in KHNP with the MR program and Byron case, it was concluded that the performance of structure can be monitored reasonably by the PSR and current plant practices on the technical basis as follows:

Firstly, each plant in KHNP has already implemented structural performance monitoring using structural procedures and the SLMS program. Also PSR confirms the integrity of structure by evaluating test results and maintenance history of structure every 10 years. The PSR evaluation items for structures are very similar to requirements suggested in NUMARC 93-01.

Secondly, performance monitoring for structure by using the MR program would be inappropriate because structure should be monitored over 5 years interval which is relatively longer than the MR monitoring interval for equipment. The MR monitoring interval is usually about 3 years or 2 refueling cycles. The MR program is considered to be basically a performance monitoring tool for active components.

Finally, the structure monitoring by the MR program could be excessive in KHNP because structure is already monitored and evaluated by the PSR program.

REFERENCES

[1] Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC 93-01, Rev. 3, NEI, 2000. 7.

[2] Industry Guideline for Monitoring the Condition of Structures at Nuclear Power Plants, NEI 96-03, Rev. D, NEI, 1996.7.

[3] Structures Monitoring, ER-MW-450, Rev. 2, Exelon, 2005.6

[4] Aging Inspection Procedure of Safety Related Concrete Structure for KORI Plant 1, 0-8-401, Rev. 3, KHNP, 2007.3.

[5] Periodic Safety Report for Young Gwang Plant 2, Rev. 0, KHNP, 2006.12.