Plant Performance Evaluation Using the Maintenance Effectiveness Monitoring Program

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1. Introduction

For the safety of nuclear systems, the quality of maintenance is getting more and more attention, as maintenance provides the foundation of the health of plant systems. The maintenance effectiveness monitoring program is an NRC regulation in the US, called Maintenance Rule (MR). It is recognized that the MR helped the nuclear industry enhance the performance of nuclear power plants whereas the MR was initiated from the regulatory needs. Even if the MR is not a regulatory requirement in Korea, Korea Hydro & Nuclear Power Co. (KHNP) is taking a strategic approach to implement the maintenance effectiveness monitoring program, adopting the general methodology delineated in NUMARC93-01[1] which provided a basis for the US Nuclear Power Plants (NPPs) to implement the MR. In this paper, the KHNP's approach to the maintenance effectiveness monitoring program, i.e., the MR program, is introduced, and an insight to the usefulness of the program will be discussed.

2. Status and Application of the Maintenance Effectiveness Monitoring Program in KHNP

KHNP is initiating the application of the Maintenance Rule program to its whole fleet including CANDU. The program development for PWRs will be completed by the end of 2009, and for CANDUs, it will be done by 2012.

2.1 Approach of the Program Development

For the implementation of the MR program, KHNP took a standardization approach for the same series of NPPs. It is a somewhat different approach from the US NPPs for which the MR program was developed by individual plants. In the standardization approach, the scoping, safety importance, and performance criteria were standardized except for the systems unique to the individual plants. However, the values of performance criteria were customized reflecting the operation and maintenance experience of each plant. The standard program was developed for OPR1000 and WH900 plant types respectively to incorporate each reactor type's characteristics in the program. Table I summarizes the statistics of the standard monitoring program for OPR1000.

Through the standardization of the implementation program, it is expected that sharing experiences and learning effects would be significantly promoted, and that the common vulnerability of the same fleet could be identified efficiently. Furthermore, the standardized performance criteria could be utilized to benchmark the plant performance parameters among the same type plants. On the other hand, the chance of enriching the knowledge base of plant engineers through the program development might be lost if applying the standardized program without knowledge-absorbing process.

Table I. Summary of the Standard Maintenance Effectiveness Monitoring Program for OPR1000

Category	Total Numbers	In-scoped Numbers
Systems	136	82
Functions	488	265
Performance Criteria	173 with 41 sub-criteria defined at train-level	

2.2 Initial Application of the Program

In this section, the results from applying the standard maintenance effectiveness monitoring program are presented. For this application, the Condition Reports (CRs) issued at the NPPs from 2005~2008 were analyzed to determine whether the CRs should be counted as Maintenance Rule Function Failures (MRFFs). The total number of reviewed CRs to determine MRFFs is about 17,000 from 8 units of OPR1000 during this period. Fig.1 shows the results of the CR analysis.

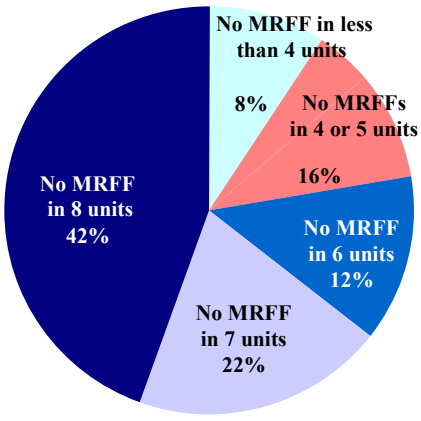

Figure 1. Fraction of Performance Criteria (PC) with the number of OPR1000 units for which the Maintenance Rule Functional Failures (MRFF) were found.

Fig. 1 shows that there has been no functional failure in 42% of the performance criteria for the whole OPR1000 units, and for less than 10% of the performance criteria, MRFFs were found in 4 or more units. It would be concluded that functions of the OPR1000 plants for

more than 40% of performance criteria have been quite stable as no MRFF has occurred in the whole units for three years. Figure 2 shows the average fraction of performance criteria according to the level of MRFFs.

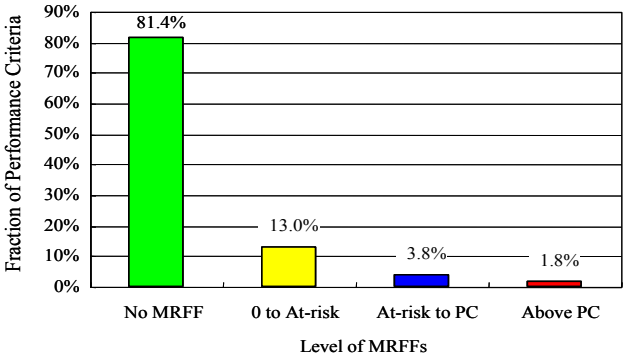

Fig. 2 Average Fraction of Performance Criteria (PC) with the level of Maintenance Rule Functional Failures (MRFF) for the OPR1000 units. Note: At-risk level means that the number of MRFFs for the corresponding PC reaches 75% of the PC or only 1 MRFF margin to the PC.

In Fig. 2, it can be said that for more than 80% of the performance criteria, no functional failure has occurred for the past three years of operation in an OPR1000 unit on average, and that for a small number of performance criteria, i.e., 2% of the total, the intensive monitoring is necessary in general. It can be concluded from Fig. 2 that functions of the individual OPR1000 unit related with about 80% of the performance criteria have been well maintained as there has been no functional failure for the past three years.

Figure 3 shows the trend of MRFFs in the past three years, which is decreasing over the past three years.

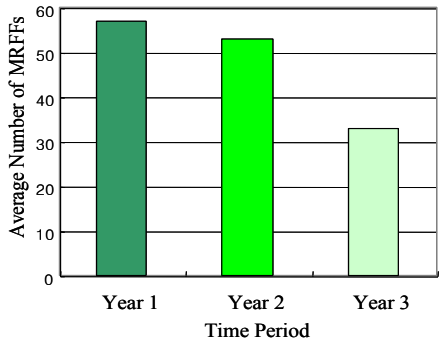

Fig. 3 Average number of MRFFs per OPR1000 plant consisting of 2 units in the time period; Year 1 is 2005 ~ 2006, Year 2 is 2006 ~2007, and Year 3 is 2007~2008.

According to the US experiences, the number of MRFFs in a year has moved up and down. As seen in Figure 4, however, the trend of MRFFs is clearly decreasing over the years. This trend may have been achieved since the performance of plants is monitored and taken care of by the MR program. Figure 4 also shows the trend of capacity factor of the US NPPs. Although it is hard to conclude that the level of capacity factor is directly linked with the number of MRFFs, keeping the capacity factor steady at such a high level may be partly due to the MR program monitoring the functional failures of plant systems with a corrective action program following the reporting from the MR program.

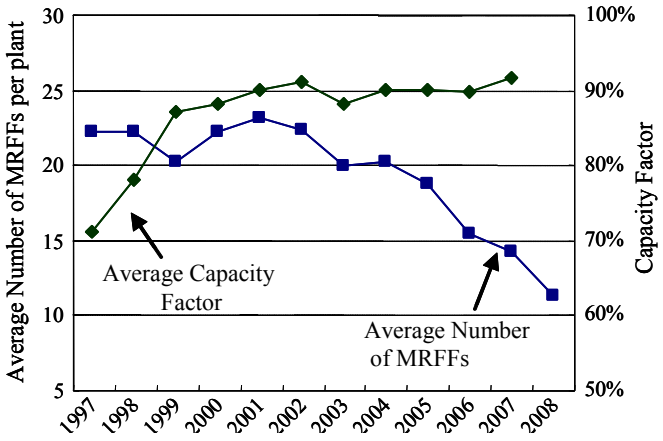

Fig.4 US plant experiences of capacity factor and number of MRFFs from 1997 to 2008: data from the US INPO (Institute of Nuclear Power Operators) EPIX Database.

3. Conclusions

The maintenance effectiveness monitoring program, i.e. the Maintenance Rule program, was developed in the standardization approach. The program was found useful in evaluating the plant performance in function levels. By applying the program to OPR1000, most of system functions were found healthy and functions to be closely monitored were identified. The usefulness of the MR program is illustrated in Fig.5. It is expected that the functional failures that would hurt the plant performance can be managed with the MR program, preventing the possibility of an unexpected sudden hike of functional failures.

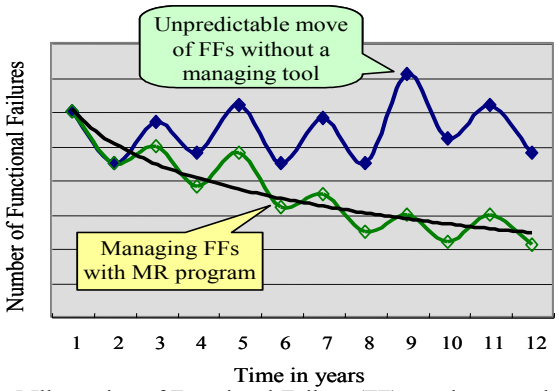

Fig.5 Illustration of Functional Failure (FF) trend expected to be with and without a managing tool.

REFERENCES

[1] Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants, NUMARC93-1 Rev.3, Nuclear Energy Institute, 2000.