

Technology Trend in the Maintenance of Nuclear Power Plants

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1. Introduction

Maintenance of nuclear power plants is an essential activity for the plant safety, reliability and productivity. For the effectiveness of maintenance activities, new technologies have been evolved and applied to nuclear power plants. In this paper, overall technology evolution is reviewed and the improvements in the plant safety, reliability and productivity are described. And the issue and some recommendation for better maintenance of Korean nuclear power plants are presented as the interim study results on the "Management and Regulatory Policy for the Nuclear Power Plant Maintenance and Equipment Reliability" under the agreement with the Nuclear Safety and Security Commission. The future trend in the maintenance technologies is also covered.

2. Approaches and Results

The following approaches were taken for the study.

- Review relevant reports on the maintenance technologies from the regulatory agencies, experts and industrial organizations such as IAEA(International Atomic Energy Agency), EPRI(Electric Power Research Institute), INPO(Institute of Nuclear Power Operations), NEA(Nuclear Energy Agency), etc.
- Investigate the application status, issues and trend of maintenance technologies in the world.
- Get insights on the maintenance technologies and its application by benchmarking of the good practices.
- Develop recommended approaches for the maintenance policy and the management methodologies.

2.1 Functions and Roles of Maintenance in the Nuclear Power Plants

Maintenance is all preventive and remedial measures, both administrative and technical, that are necessary to detect and mitigate degradation of a functioning structure, systems and components(SSCs) or to restore to an acceptable level the performance of design functions of a failed SSC. The range of maintenance activities includes servicing, overhaul, repair and replacement of parts, and often, as appropriate, testing, calibration and inspection. Maintenance is the essential activity for the plant safety, reliability and productivity. The U.S. Regulatory Agency concluded that proper maintenance is essential to plant safety and issued the Maintenance Rule(10 CFR 50.65) in 1991.

In Korea, twenty percentage of the forced outages for the past ten years was caused by the maintenance related problems. It is reported that more than five percentage

of increase in the capacity factor could be achievable by the well established maintenance strategy. And the maintenance cost is about twenty five percentage of the non-fuel operation and maintenance cost.

2.2 Evolution of Maintenance Technologies

Many maintenance technologies in the industrial sector have continuously been evolved since 1930's and some effective technologies such as RCM(Reliability Centered Maintenance), Predictive Maintenance(or Condition Based Maintenance; CBM) and OLM(On-Line Maintenance) was developed in 1990's. (Table 1)

Table 1. Evolution of Maintenance Technology

1930's	1980's	1990's
1 st Generation Maintenance (Reactive Maintenance)	2 nd Generation Maintenance (Planned Maintenance)	3 rd Generation Maintenance (Optimized Maintenance)
o Run-to-failure Maintenance	o Run-to-failure Maintenance o Periodic Maintenance o o o	o Run-to-failure Maintenance o Periodic Maintenance o Reliability Centered Maintenance o Predictive Maintenance (CBM) o On-Line Maintenance o Proactive Maintenance o Total Productive Maintenance

Nowadays most of nuclear power plants utilize all of the above maintenance technologies and optimize the use of the above maintenance technologies on each system and component by taking into account the criticality in function and the severity of its failure.

2.3 Policies and applications in other countries

For the optimized maintenance some countries such as U.S., Canada, and Spain issued the regulatory requirements for the maintenance during the 1990's. In other countries such as France, Germany and U.K. the optimized maintenance have been applied through the regulator's involvements (for example, maintenance program review, site inspection) under the existing regulatory requirements. And a lot of studies and surveys from IAEA, EPRI, NEI, etc. have been conducted for the detail application of the optimized maintenance. The key elements for the successful application of the optimized maintenance are as follows.

- Establishment of the regulatory requirements for the effective maintenance.
- Application of new maintenance technologies such as RCM and CBM.
- Regulator's review and continuous improvement of maintenance program ,
- Utilization of Probability Risk Assessment(PRA) for the evaluation of maintenance activities.

- Utilization of maintenance performance indicators for the evaluation for the maintenance effectiveness.

It is reported that much improvements in the plant safety, reliability and productivity have made through the optimized maintenance. In the case of U.S. nuclear power plants operational and reliability improvements have resulted in a factor of five reduction in the automatic scram rate and much improvement of capacity factor (Figure 1&2)

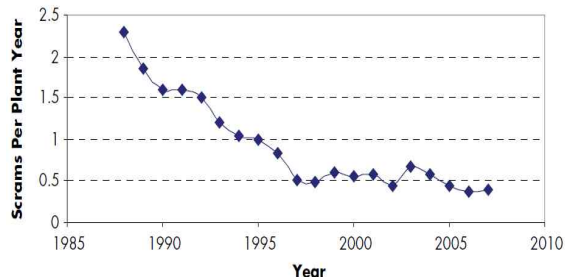


Figure 1. U.S. scram rate reduction

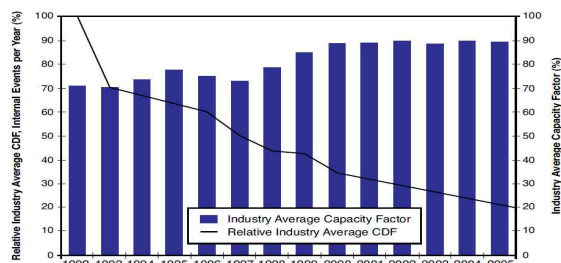


Figure 2. Plant capacity factor performance versus core damage frequency risk levels in U.S. Plants

It is noted that the OLM has heavily contributed to these improvements. EPRI reports stated that the OLM can enable nuclear plants to improve equipment reliability, reduce risks of component failures, extend fuel cycles, shorten refueling outages, and optimize work planning, all without compromising plant and personnel safety

2.4 Policies and Applications in our country

Many studies on the maintenance policies and technologies were performed in our countries since 1999, but no regulatory requirements have been issued by this time. The optimized maintenance has been applied to Korean nuclear power plants by the utility company. The current issue in the maintenance is the applicability of OLM because it has been an important consideration for the establishments of regulatory policy while it is one of good reasons in other countries. In the near term this issue need to be resolved for the better sustainability of Korean nuclear power plants.

2.5 Future trend in the maintenance technology

The following technologies and improvements are foreseen in the future.

- Continuous improvement for better maintenance program and regulator's active involvements.
- Extensive application of OLM.
- Development of sensing technologies for on-line condition and performance monitoring of systems and components.
- Development of proactive maintenance technology.
- Establishment of accurate and reliable database on failure rates and maintenance periods for each type of components.
- Increasing usage of Information Technology for modeling and simulation for the prediction of failures and integration with configuration and knowledge management.

3. Conclusions

Maintenance is the essential element for the enhancement of plant safety, reliability and economics and also for public safety. Therefore the regulator's involvements and the utility's active participation is inevitable for the better maintenance. For the better sustainability of our nuclear power plants the followings are recommended.

- Establishment of regulatory requirements and guides for maintenance.
- Active participation from the utility company and full support from the regulator.
- Establishment of the good maintenance program and continuous improvement.
- Application of OLM on the safety related and non-safety related components by step-by-step approach.
- Improvement PRA technology for the accurate and reliable risk analysis.
- Continuous studies and researches for the development of new maintenance technologies.
- Continuous training and cultivation for the qualified maintenance personnel.

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