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The Application of RMTS, SFCP to APR+

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1. Introduction

The risk informed application (RIA) has enhanced the safety and flexibility of operating nuclear power plants (NPPs). RIA technology in Korea Hydro and Nuclear Power Co. (KHNP) associated with operating the power plant has been matured through PSA and risk monitoring. Also, the methodology of RIA is considered for the application to a new plant design to achieve competitiveness in nuclear industry. From this point of view, the APR^+, an advanced power reactor developed by KHNP, has considered the application of RIA, which includes the risk-managed technical specification (RMTS) and the surveillance frequency control program (SFCP).

The methods of the RMTS and SFCP specified in the corresponding NEI guidelines are briefly summarized, and then these programs are incorporated into the APR+.

2. RMTS and SFCP

The RMTS allows completion time (CT) to be flexibly determined on site by the licensee using PSA results based on the real time plant configuration. The SFCP relocates the surveillance frequency (SF) for licensee's control using PSA and operating experiences. Their implementation guidelines were developed by the Nuclear Energy Institute (NEI) as NEI 06-09 for the RMTS and NEI 04-10 for the SFCP. Both have been approved by the nuclear regulatory commission.

2.1 *Risk-Managed Technical Specification (RMTS)*

Risk management thresholds for RMTS program application are established quantitatively by considering the magnitude of the instantaneous core damage frequency (CDF), instantaneous large early release frequency (LERF), incremental core damage probability (ICDP), and the incremental large early release probability (ILERP) for the plant configuration of interest. The risk management thresholds presented in Table 1 are the basis for RMTS program action requirements.

Table 1: RMTS Risk Thresholds to calculate RICT

Parameter	CDF	LERF	ICDP	ILERP
Criterion	$< 10^{-3}$	$< 10^{-4}$	$< 10^{-5}$	$< 10^{-6}$

In the example shown in Fig. 1, at time = 20 days, the second SSC (i.e., the one which became inoperable due to the emergent event at time = 5 days) is restored to service (i.e., returns to a technical specification operable condition). At this time, the risk-informed CT (RICT) may be recalculated to reflect the new plant configuration accounting for the cumulative risk accrued during the evolution from time = 0. In this configuration, the 10^{-5} ICDP is not reached until the 30 day back-stop CT. The RICT for System 1 may now be reset to 30 days from the time the first system became inoperable. Also, notice that since the cumulative risk at this point is greater than the 10^{-6} ICDP threshold; implementation of appropriate compensatory risk management actions continues to be required.

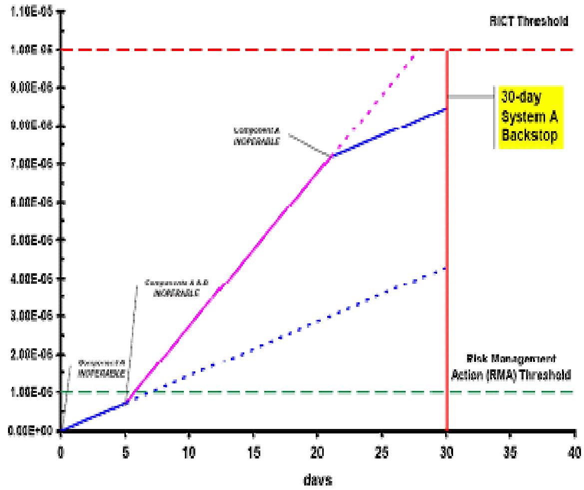

Fig 1. Configuration Risk Management – Illustration of Risk Accrual for RICT Calculation

The following subjects are the requirements to establish the RMTS specified in NEI 06-09. The licensee who wants to implement the RMTS must satisfy these requirements and receive the approval of the NRC.

- Establishment of the station procedure of the Configuration Risk Management Program (CRMP) process, specifying the station functional organizations and personnel responsible for each action of CRMP implementation,
- Training of responsible personnel,
- Preparation of a PSA model to meet the technical adequacy requirement of NEI 06-09,
- Preparation of an appropriate CRM tool to calculate RICT.

2.2 *Surveillance Frequency Control Program (SFCP)*

This methodology uses a risk-informed, performance based approach consistent with RG 1.177. A multi-disciplinary plant decision-making panel is utilized to evaluate determinations of revised surveillance frequency (SF), based on operating experience, test history, manufacturer's recommendations, codes and standards, and other factors, in conjunction with the risk insights from the PSA.

Implementations guideline of SFCP (NEI 04-10) are follows: Selection of STI candidate (Plant Health Committee Review), STI Evaluation Form with guidance for completing the form, engineering evaluation of proposed STI change, risk assessment of proposed STI change, qualifications, and review process, STI change implementation, STI change performance monitoring/IDP (Independent Decision making Panel) periodic review, and List of Surveillance Frequencies Control Process

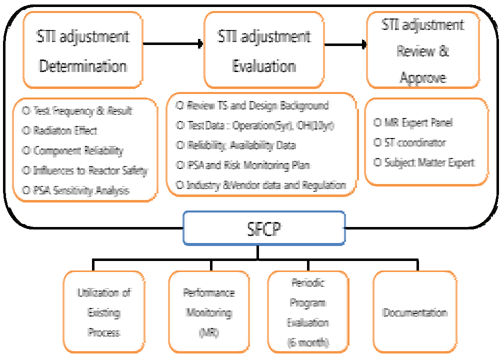

Fig 2. Surveillance Frequency Control Program

3. Application of the RMTS and SFCP to APR+

In order to implement the RMTS and SFCP into the APR+, the following steps should be considered in advance.

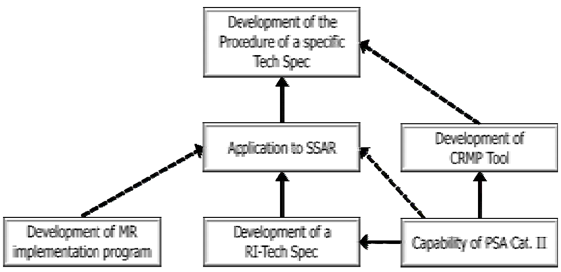

Fig 3. Application process of the RMTS and SFCP to APR+

Step 1. Capability of PSA category Ⅱ

The application of RMTS and SFCP requires category Ⅱ level in terms of the ASME PRA Standard. The ASME standard of internal events consists of a total of 197 supporting requirements in the Korean standard nuclear power plant (KSNP). Within the 197 supporting requirements, 73 elements in capability category 1(Table 2) are used as generic data/models that are acceptable except for the need of unique design and operational features of the plant.

Table 2. Breakdown of capability category Ⅱ supporting requirements of the ASME PSA standard (KSNP)

Classification	Same as capability category 1	Higher than capability category 1
PRA Elements	73	124

Approximately 37% of the supporting requirements for capability category 2 PSA can be met in the design stage. The remaining 63% can only meet to the plant specific detail design which is developed after fuel load.

Step 2. Development of RI-TS

The PSA to support the risk-informed TS will be developed in three phases.

- Phase 1. The PSA will be developed based on plant specific information available.
- Phase 2. During the construction of APR+, plant specific information such as plant specific procedures (e.g. emergency operation procedure and abnormal operating procedure) and as built detail design will be incorporated in the PSA
- Phase 3. In the plant operation, the operating history will be reflected in the PSA such as in initiating event analysis and data analysis and all capability category 2 requirements of the PSA standard can basically be achieved at this phase

Step 3. Application of SSAR

The application of SSAR uses NEI 04-10 and 06-09 based on the establishment of RI-TS.

Step 4. Development of CRMP tool

The risk monitoring systems and outage risk indicators of NPPs have already been developed and applied to operating NPPs. These programs are applicable to advanced design reactors as effective CRMP tools, and the development of the specific TS.

4. Conclusions

This paper demonstrates the applicability of the RMTS and SFCP to the APR+. These programs provide a competitive advantage to the new plant design that could be achieved by means of: making components more compact, simplifying low reliability systems into a single system, and getting rid of redundancy by using more reliable components. However, more comprehensive studies are required for practical implementations in terms of the risk assessment, performance monitoring, and the application methodology of PSA technologies. Furthermore, it is required for KHNP to obtain approval from the regulatory body in order to establish the RI-TS. The education and training associated with the RIA and PSA are also required.

REFERENCES

[1] Nuclear Energy Institute, "Risk-Informed Technical Specifications Initiative 4b, Risk-Managed Technical Specifications (RMTS) Guidelines," NEI 06-09 Revision 0 (2006).

[2] Nuclear Energy Institute, "Risk-Informed Technical Specifications Initiative 5b, Risk-Informed Method for Control of Surveillance Frequencies," NEI 04-10 Revision 1 (2007).