Proposed Risk Thresholds during Power Operations for On-Line Maintenance

Hee Seung Chang*, Jung Wun Kim

KHNP Central Research Institute (NETEC), Korea Hydro & Nuclear Power Co. (KHNP), 25-1 Jang-dong, Yuseong-gu, Daejeon, Korea 305-343
**Corresponding author: daniel@khnp.co.kr*

1. Introduction

The 10CFR50.65 requires risk assessment and management prior to performing maintenance activities in nuclear power plants for the safety related functions that are significant in terms of public health and safety. The nuclear power industry guidelines for risk assessment, NUMARC 93-01 Section 11 endorsed as Regulatory Guide 1.160 by the US Nuclear Regulatory Committee, describes that quantitative, qualitative or blended methods are required in order to assess risk when there is simultaneous removal from service of multiple structures, systems, and components (SSC) [1]. The US nuclear industry has used risk assessment tools and established thresholds for on-line risk in order to manage the increase in risk as a result of maintenance and/or tests. The various on-line risk thresholds used in US nuclear power plants, and described in the above documents, are compared in this paper. Methodologies for optimized risk thresholds for Korean nuclear power plants will be discussed and proposed.

2. Risk Evaluation Scope and Methods

2.1 Scope of risk assessment

The scope of the SSC to be assessed may not include all SSCs because 10CFR50.65 (a)(4) requires the SSC to be limited to those events that are significant to public health and safety. Thus, the assessment scope is limited to the SSCs included in the scope of a plant's level one internal event Probabilistic Safety Analysis (PSA) and the SSC that is determined to be of high safety significant using the Delphi methods by an Expert Panel. The risk assessment of a single SSC for removal from service for a planned time is not required if it is performed within the outage time allowed in the Technical Specifications. However, unusual external conditions such as severe weather or offsite power instability may be considered. When multiple SSCs are simultaneously out of service for maintenance, a risk assessment should be performed using quantitative, qualitative or blended methods.

2.2 Risk evaluation methods

One risk evaluation method is a qualitative approach that addresses the impact of the maintenance activity upon the key safety functions, which include containment integrity, reactivity control, reactor coolant heat removal, and reactor coolant inventory control for the power operation. Another method for risk evaluation is a quantitative approach, which can entail two different approaches. The first approach is to calculate the incremental core damage frequency (CDF) or incremental large early release frequency (LERF), which is the difference of the baseline CDF or LERF for maintenance configuration. NUMARC 93-01 requires that the configuration for maintenance does not exceed a CDF value of 1.0E-3. The second approach is to assess the incremental core damage probability (ICDP) or incremental large early release probability (ILERP) which assesses the risk of considering the duration of the work with an incremental CDF or LERF. In this case, the temporary changes with the risk increments greater than 1.0E-5 of CDP or 1.0E-06 of LERP are considered as potentially risk significant and require management oversight [2].

3. On-line Risk Thresholds

On-line risk color is used to manage the risk and establish a mitigation action in order to minimize the risk increase on the maintenance configuration. The methods for determining the risk color are varied and the thresholds are different at different nuclear power plants. Four key methods and typical thresholds are used in US nuclear power plants and are presented in Table I.

Table I: Examples of typical on-line risk thresholds according to each approach.

	Green	Yellow	Orange	Red
Absolute Incremental CDF	< 1E-4	> 1E-4	> 5E-4	> 1E-3
Relative Incremental CDF	< X2	> X2	> X10	> X20
ICDP	< 1E-6	> 1E-6	> 5E-6	> 1E-5
Allowable Configuration Time (ACT)	< 10 hrs	> 10 hrs	> 24 hrs	> 120 hrs

Some utilities use the allowable configuration time (ACT) method which translates the ICDP to an allowable out of service time for maintenance or surveillance tests within an acceptable risk. This method may be a better communication tool with plant staff, including workers who are not familiar with the CDF or PSA.

The EPRI survey result states 76% of responding plants in the US use ICDF to determine on-line risk thresholds, while 46% of those use CDP methods. For the plants that responded with the use of ICDF, 56% use a relative incremental CDF, which is the use of multiple baseline risk values to establish risk thresholds, while 36% use absolute risk values [3]. From these survey results, the on-line risk thresholds for pressurized water reactors are shown in Fig. 1. The figure shows that the threshold for red requiring stringent mitigation actions or limited to access is 1.0E-03 in most US plants. The orange criteria are formed between 1.69E-04 and 5.0E-04. There is not a significant difference between the absolute values and relative values of the incremental CDF.

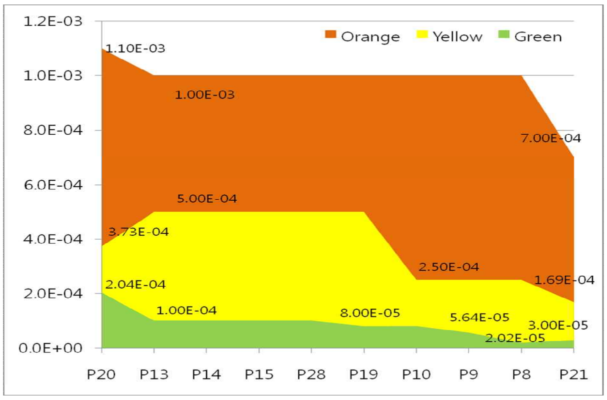

Fig. 1. On-line risk threshold in US nuclear power plants by translating multiple baseline risk values to absolute values.

An on-line risk monitoring program, called the Risk Monitoring System (RIMS), has been developed and used in Korea Hydro & Nuclear Power Co. (KHNP). It is used to manage the risk increase during maintenance and surveillance tests during power operation. It hasred, orange, yellow, and green risk colors with 20 times, 10 times, and 2 times multiple baseline risk. . The risk thresholds are determined with reference to the US utility standards in order to minimize disagreements and maximize ease of use regardless of the baseline risk of the plants [4]. However, the risk thresholds are too conservative. For example, the red color threshold is 1.09E-04, which is a factor of 10 times lower than that of the US plants as shown in Fig. 2.

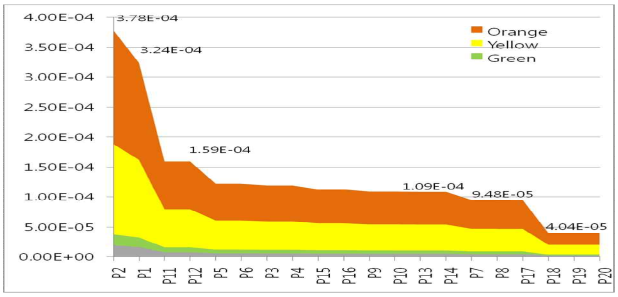

Fig. 2. On-line risk threshold in Korean plants described in terms of absolute risk value.

One Korean nuclear power plant has experienced several orange color activities even though it was undertaking a surveillance test such as an auxiliary feed water performance test or ESFAS auxilary relay test, which took nine minutes each. Using the US thresholds, these tests would be yellow risks or green risks if they are counted as ICDP values.

The proposed methodology for on-line risk thresholds for Korean plants is a combination of the absolute and relative approaches such as the red risk threshold with an absolute risk value is reasonable to manage significant risk, and the orange and yellow risk thresholds are set using the ICDP values to manage the risk and duration for on-line maintenance.

4. Conclusions

There are several approaches to assessing risk and establishing on-line risk thresholds as discussed above. The current risk thresholds of RIMS are too conservative compared with the experiences of the US utilities and the methodologies in NUMARC 93-01 Section 11, because it was developed with the focus on risk monitoring itself rather than risk management of work activities. In Korea, on-line maintenance has been introduced and is being undertaken at a pilot plant. The plan is to implement the process across the plants and expand the scope of work during the power operations. However, the on-line risk threshold should be reestablished in order to reasonably manage risk after contextual considerations. The determination of appropriate methods or a combination of methods are unique activities for each plant; thus, further study and consensus are required in order to establish appropriate risk thresholds in Korean nuclear power plants.

REFERENCES

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[3] EPRI, Review of Current Practices for Configuration Risk Management at Nuclear Power Plants, EPRI TR-1015098, 2007.
[4] KHNP, Development of Risk Monitoring System for Y-3,4, Section 3.1, 2005.