

Development and Application of Component, System, and Train Importance Evaluation Tool, SSIA based on SAREX

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1. Introduction

10 CFR 50.69, issued by the U.S. Nuclear Regulatory Commission (NRC) in 2004, is an innovative regulation that allows for safety classification change for Structures, Systems, and Components (SSCs) in nuclear power plants from a deterministic approach to a Risk-Informed approach. SSCs are classified by RISC (Risk-Informed Safety Categorization), and different treatment requirements are applied based on the categorization results. This study introduces a method for evaluating the importance measures of components, systems, and trains using the SSIA (Systematic SAREX Importance Analyzer) program, which performs importance measure assessments for PSA models by utilizing SAREX, the PSA software for RISC classification. Furthermore, it proposes methods for utilizing the analysis results.

2. Risk-Informed Importance Evaluation Methods

10 CFR 50.69 applies the concepts of Risk-Informed and Performance-Based regulation to focus regulatory resources on equipment that are actually important for safety, rather than regulating all safety related equipment at the same treatment level. The previous regulatory framework with uniform and conservative treatment requirements for individual equipment has been leading to issues such as increased maintenance costs and unnecessary burdens related to the special treatment of inspection, testing, reporting, and quality assurance.

To address these issues, the U.S. Nuclear Energy Institute (NEI) proposed a methodology for evaluating the safety importance of equipment based on Probabilistic Safety Assessment (PSA) and categorizing equipment according to its importance. 10 CFR 50.69 categorizes SSCs into four RISC categories based on risk importance.

To categorize equipment into these categories, the importance measures of SSCs should be evaluated using Probabilistic Safety Assessment. The main importance measures utilized are FV (Fussel-Vesely) and RAW (Risk Achievement Worth). Generally, components, systems, and trains with importance

measure of FV > 0.005 or RAW > 2 are considered to be risk significant.

2.1 Importance Evaluation Method of NEI-00-04

NEI-00-04 serves as the 10 CFR 50.69 SSC Categorization Guideline. It provides a method for categorizing Structures, Systems, and Components to apply the U.S. federal regulation 10 CFR 50.69 to operating U.S. nuclear power plants.

2.2 Importance Evaluation Method of EPRI-TR-105396

EPRI-TR-105396 is a nuclear power plant risk management guideline that presents methods for risk assessment according to changes in plant Configuration and risk management during operation.

This method significantly has affected the application of the Maintenance Rule (10 CFR 50.65(a)(4)) and the development of the Risk Management Action (RMA) framework.

2.3 Other Importance Evaluation Methods

Alternatives such as the Balancing Method and Direct Method have been studied to replace the existing NEI methodology (STP Method).

2.4 SAREX Importance Evaluation Method

The SAREX program basically provides functions to evaluate importance for basic events and groups composed of basic events. It calculates importance measures of FV, RAW, RRW, and BB but doesn't provide a function to evaluate importance measures for SSCs.

Accordingly, a program named SSIA (Systematic SAREX Importance Analyzer) was developed to perform SSCs importance measure calculation in a very effective manner. SSIA supports three methods: the NEI-00-04 methodology, a method to evaluate importance directly from Cutsets, and a method to re-evaluate the quantification model.

3. Importance Evaluation Methods with the SSIA

The SSIA is a Windows based software developed using SAREX library. The program screen is shown in Fig. 3.1 below.

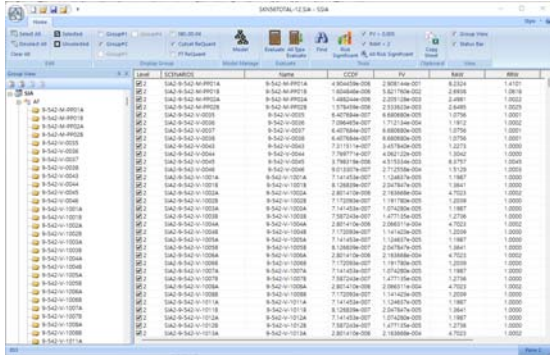


Fig 3.1 SSIA program screen shot

The SSIA allows for hierarchical tree structures, enabling listing with the order of system, train, and component. It can evaluate the importance measures of systems, trains, and components using a single input file.

3.1 Integration with SAREX

When SSCs are mapped to the basic events in the SAREX database, a list for importance evaluation by SSCs can be created. This can be generated as an input file for the SSIA.

3.2 Importance Evaluation

The SSIA supports the following three methods for importance measure evaluation:

- NEI-00-04 Method:
- Cutset Re-Quantification:
- Fault Tree Re-Quantification:

After the importance measure evaluation, the SSCs with high importance by each method are displayed. Furthermore, the combined Overall Risk Significant generated by integrating the risk significant SSCs from each method.

4. SSIA Application to APR1400

Using the APR1400 internal events PSA model, the three importance measures were evaluated by SSIA. The combined Overall Risk Significant was compared. The Fault Tree Re-Quantification method found around 330 risk significant components out of 823 components regardless of the truncation value. The NEI-00-04 and Cutset Re-Quantification methods showed results similar to the Fault Tree Re-Quantification results when the cutoff is used which makes the CDF converged.

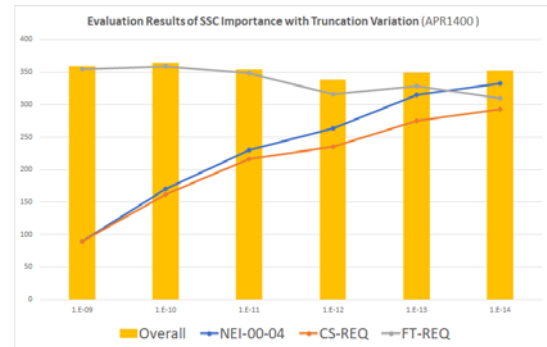
Table 3.1 shows the number of importance evaluation results by truncation value. The number of combined Risk Significant components was found to be

349 at the truncation value of 1.E-13 where the base model's minimal cut sets sufficiently converged (within 5%). The total number of SSCs was consistently around 350, indicating that assessing SSCs importance based on the overall results is practical. Figure 3.2 illustrates the Overall Risk Significant (bar graph) and the number of Risk Significant SSC by importance method, as processed by the SSIA.

Table 3.1 SSIA Evaluation Results by Truncation Value

Trunc	1E-9	1E-10	1E-11	1E-12	1E-13	1E-14
NEI	90	170	230	264	315	333
CS-Req	90	162	216	235	275	293
FT-Req	355	359	349	316	329	310
Overall	360	364	354	339	349	352

Fig 3.2 Evaluation Results of SSC Importance with Truncation



Risk Significant SSCs for RISC should be selected by reliable and solid technical basis. The SSIA confirmed that the number of combined Overall Risk Significant was relatively consistent regardless of the quantification methods reflecting PSA truncation values. When only the NEI-00-04 method or Cutset Re-Quantification method is used, the MCSs generated with sufficiently low truncation should be used.

5. Conclusions

The SSIA can evaluate SSCs importance measures with the three methods: NEI-00-04, Cutset Re-Quantification, and Fault Tree Re-Quantification. The combined Overall Risk Significant results remain consistent regardless of the truncation of quantification model. When only the NEI-00-04 method or Cutset Re-Quantification method is used, the MCSs generated with sufficiently low truncation should be used.

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