Development of Safety Significance Analysis System for Risk-Informed Decision Making

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INTRODUCTION

Regulation of nuclear power plant (NPP) has been studied to make more reasonable, effective and efficient decisions based on risk and performance information [1]. For that reason, Korea Institute of Nuclear Safety (KINS) has developed a framework of regulation by risk and performance bases [1][2][3][4]. As a part of this graded regulation program, Significance Evaluation of Inspection Findings (SEIF) was developed [2].

We have developed a safety significance analysis system to improve the functions of SEIF [5]. The accessibility of this system is necessary to be enhanced so that the inspectors of KINS who are not familiar with risk-informed decision making (RIDM) can easily carry out the risk information, and the PSA department carries out the detailed evaluation if necessary, and the result of the evaluation can be systematically managed [5]. The inspectors can understand risk information easily using this system. The members of probabilistic safety assessment (PSA) department can organize the risk information using this system.

STRUCTURE OF SAFETY SIGNIFICANCE ANALYSIS SYSTEM

The structure of safety significance analysis system consists of three steps as shown in Fig.1. Step 1 is a web-based software that can be used by all KINS inspectors without expertise in PSA to analyze the approximate preliminary significance of risk. The results obtained through the step 1 can be sent to members of PSA department for detailed analysis. The software of Step 1 is called SEM (significance evaluation management system) and has been developed by KINS and FNC Technology Co., Ltd.

Members of PSA department can perform accident sequence precursor (ASP) or significance determination process (SDP) analysis using PC based software of Step 2. This software is called RYAN (risk analysis for ASP/SDP of NPP) and has been developed by Korea Atomic Energy Research Institute (KAERI). If meaningful results are obtained by the RYAN, a detailed analysis to obtain the point of view from the risk insight is performed in step 3 and MPAS model is used in the exiting AIMS program.

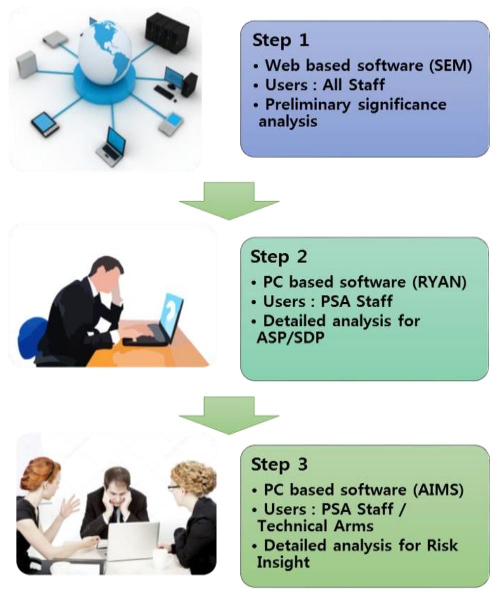

Fig 1. Steps of safety significance analysis system

DEVELOPMENT OF WEB-BASED SAFETY SIGNIFICANCE ANALYSIS PROGRAM

SEM is web-based software for all staff without knowledge of PSA. The functions of SEM are as follows:

- Performance of safety significance analysis based on logic of AIMS
- Systematic management of history of safety significance analysis
- Calculations of the core damage frequency (CDF) and deviation of core damage frequency
- Window Server (CDF Calc) for quantification functions
- Web program (Web connector) for sending computation command to CDF Calc

SEM is developed to access easily by users who are non-specialists. We removed all items that are difficult for the user to understand or require background knowledge. A management function that can be easily manage the results of users' evaluation history or detailed evaluation are implemented.

The SEM provides key functions such as managing the evaluation history, performing safety significance evaluation as shown in Fig.2, viewing the preliminary evaluation results as shown in Fig.3, and setting and manage the environment. The SEIF utilizes system information, equipment information, and system functions as inputs, and qualitative and quantitative significance evaluation results were obtained.

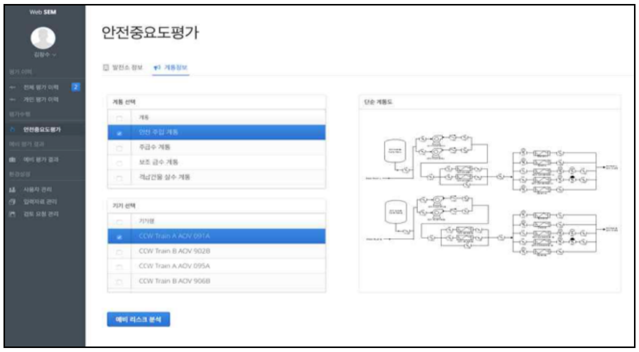

Fig. 2. Inputs for qualitative significance evaluation

In the case of SEIF, the user needs the concepts of PSA model to choose the input well and the users should install the SEIF to their PC. This point reduced the availability of SEIF to users. Moreover, the unnecessary information were shown in a viewpoints of staff who are not familiar with PSA. On the other hand, the SEM is not necessary to install the users' PC. The input of SEM is the failed component in safety system. To be simple and intuitive, qualitative significance evaluation is deleted. The preliminary evaluation results becomes simpler. The result is deviation of core damage frequency between the reference model and calculated results according to input. Significance level can be shown as color. White is ineffective condition in a point view of risk, red is serious condition, and yellow is abnormal condition. If the users consider that a detailed analysis is necessary, the user can ask the detailed analysis in the SEM. All history of safety significance analysis can be systematically managed.

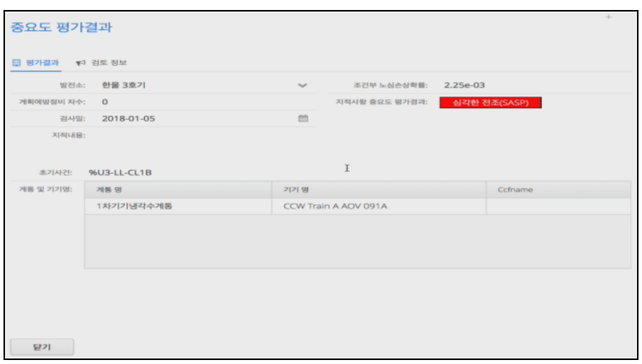

Fig. 3. The preliminary evaluation results

CASE STUDY FOR VALIDATION OF SAFETY SIGNIFICANCE ANALYSIS SYSTEM BASED ON INSPECTION FINGINGS AND NONCONFORMITIES

Criteria of significance level are necessary to identify properly in considering the safety level of Korea NPPs. The proper criteria of significance level can be identified using the history of inspection finding and nonconformities. From 2010 to 2017, about 420 inspection findings from all plants in Korea have been identified. The findings are categorized according to types of finding, relationship with PSA model, degradation of performance, and surrogate. 118 finding are related PSA model. Among 118 findings, the proper cases will be selected and applied to SEM and RYAN to identify the criteria of significance level.

If the nonconformities are found, they should be reported to the Commission in accordance with its notice upon finding nonconformance in any safety-related equipment or facility that fails to meet the standards. [6] From 2014, 26 nonconformities are reported. Among 26 nonconformities, the cases which are safety equipment and related to degradation of performance will be also applied to SEM and RYAN.

SUMMARY AND FURTHER STUDY

We developed the safety significance analysis system for both all KINS inspectors without expertise in PSA and PSA team members. To increase accessibility of KINS inspectors, the SEM is developed as web-based software. The members of PSA department can be required the detailed analysis by inspectors using SEM. Beta test has been performed, thus the design will be improved to be more convenient based on test results. Case study has been performed to identify the criteria of significance level of SEM based on the inspection finding and nonconformities. In the further study, the common cause failures will be considered in SEM.

ACKNOWLEDGMENTS

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