An analysis of the requirements for the supporting DB on Level-3 PSA code

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1. Introduction

As a part of nuclear safety research, a Korean specific Level-3 PSA code was set for development. Similarly, in the field of nuclear safety research, there have been many studies on improving the safety and reducing the risk based on simulation data and experimental data.

The results of various researches have been accumulated, along with large amounts of data. On the other hand, with the simulation code, a supporting database for the user might be need. And in case of lots of data for support features, it needs to construct database for the supporting. In this study, the requirements for the supporting database is studied using a proper scheme for the management of large amount supporting data.

2. Methods and Results

In the nuclear safety fields, various research methods are used to reduce risk. In this section, the recent status related the data management and database of PSA safety research is reviewed, and a research plan through a database is inspected.

2.1 Current Status for Level-3 PSA code

The Level-3 PSA is a field of assessment for an off-site consequence analysis of a radiation leakage accident using the probabilistic method. The execution of a Level-3 PSA is a somewhat complicated and enormous job, and is performed using a code (computer program) [1]. Most widely used code for a Level-3 PSA is the MACCS2 code, which was developed by SNL in USA. In addition, the OSCAAR code was developed by JAEA in Japan, and is utilized only for research. And COZYMA and CONDOR codes are also used.

Based on the instruction of the Fukushima accident, the necessity of Level-3 PSA execution has increased regarding radiation leakage and the off-site influence of radiation. In particular, a Korean specific Level-3 PSA is needed due to the demand of the latest technology, and social and legal requests for intensified safety.

The practical code to execute the Level-3 PSA is the MACCS2 code of the USA. The technology of MACCS2 as foreign has limitations compared to domestic environmental characteristics. Based on this insufficiency, a code for a Level-2 PSA needs to be developed with domestic technology reflecting environmental characteristics.

In particular, after the accident at the Fukushima NPP(nuclear power plant), enormous progress had been made in the field of application technology in a Level-3 PSA such as the atmospheric diffusion model and the radiation health analysis model. According to this, the need for the execution of a Level-3 PSA has arisen.

Recently, the international technical trends and the research status were considered and checked. The major technical fields are classified such as radiation source, NPP site information, atmospheric diffusion module, ocean diffusion module, exposure dose model, ecosystem model, emergency response assessment, health impact assessment, and economic impact assessment. Related to these technical fields, major important models and data are also classified [2].

Through this process, the 5 core models for the Level-3 PSA code were checked and compared: the diffusion model, exposure dose model, exposure pathway model, emergency response model, and health impact model. In addition, a roadmap was established and the strategies were set up.

As the first step for the code development, the requirements contained in the code were classified. Based on these requirements, the code design and implementation phase is being processed.

2.2 Database of the Nuclear Field Research

In the severe accident fields (Level-2 PSA), there are many requirements for the analysis of a severe accident. In addition, there are various methods related to this analysis such as accident management, Level-2 experimental data analysis, code simulation data, and an optimized strategy.

In the field of severe accident experiment, a TROI experiment had been performed for a long time on the damage impact and mitigation plan of the containment vessel. The experimental data need to be arranged systematically and have to be used for an easy and rapid data search. An integrated database system was constructed for the TROI experimental data [3].

For the optimum assessment of Level-2 risk, there were database constructions of uncertainty analysis related to early containment failure and late containment failure of severe accidents [4,5]. It contains the uncertainty analysis data for the containment pressure behavior in the case of a severe accident. The uncertainty analysis data were acquired from a MAAP code simulation, which was developed

in NRC and widely used in severe accident analysis. Similarly, the database construction of a severe accident analysis exists. For the database system, the representative scenarios of a severe accident were selected, and thermal hydraulic and source term analyses have been performed using the MAAP code under different scenarios.

For the SFP(spent fuel pool) in an NPP, the database system of a severe accident risk assessment was constructed [6]. Because the safety of an SFP has also became an important issue after the Fukushima accident, the data for the risk assessment of an SFP are also needed in various scenarios. The assessment models were selected based on SFP LOCA(Loss of Cooling Accident) and LOPI(Loss of Pool Inventory).

There was database construction of genetic resources of radiation breeding. Although the necessity for researches of genetic resources of radiation breeding has being increased, there are limits in consecutive researches. A database is needed on the genetic resources for the assurance of continuing research effectiveness [7].

In HRA (Human Reliability Analysis) fields of a Level-1 PSA, there is a database based on simulator training data. In a Level-1 PSA, reducing human error is a critical issue. Sufficient and reliable human performance data collection is a prerequisite for the safety of nuclear power plants [8]. For the systematic acquisition and management of the operator's performance data, the HRA database was constructed. Through the HRA database, the raw data were collected and stored for the HRA analysis and supported as a basis for the quantitative results, such as the proportional importance of human error probability or performance shaping factor. The above contents are summarized in Table I.

2.3 Requirements and Plan for database

In a Level-3 PSA, two kinds of database were considered. One is for a database of support functions for document referenced in the Level-3 PSA code. The other is for the results of the Level-3 PSA code simulation.

As a first one, the supporting database are used for conjunction with the Level-3 PSA code during the run-time of the code. And as second one, similar to the Level-2 PSA code results, for the results of the Level-3 PSA code simulation, the result type and the purpose of usage for the simulation results will be considered in advance. According to the function of the code and the scope covered within the code, the code results can be diverse.

The scope of the supporting database is around the execution of the Level-3 PSA code. The 'HELP' function for the users of Level 3 PSA code helps code execution. The supporting database consist of keyword and its description. The description means an auxiliary description referenced by the 'HELP' function during code simulation. An example of supporting database is shown in Fig. 1. The key documentation for the description to be used in the supporting DB has been obtained. And some documents are surveyed for more trustful description.

Table I: Existing DB cases related nuclear field research

Item / DB	Data Characteristic	Reported Year
Fire Event DB	Fire DB (OECD/NEA) and Event Sequences	2010
DB for Severe Accident Analysis	Phenomenological Information for the 54 Accident Scenarios	2010
DB for Phenomeno-logical Uncertainty Analysis	Database of Early/Late Containment Failure for Level 2 Risk Optimum Assessment [4,5]	2010 2011
DB of Risk and Performance Information	PSA object component and Cable Data	2011
DB for Severe Accident Risk	Severe Accident Analysis Data based on MAAP code Simulation	2012
DB for genetic resources by radiation breeding	Mutation Gene Data [7]	2014
DB for TROI experiment	35 Experimental Conditions and 29 Results for 72 TROI tests [3]	2014
DB of Risk Evaluation	Risk Evaluation for SFP Severe Accident	2016
DB of Evaluation for Fuel Slug	Fuel Evaluation for the alloy composition of the rare earth content	2016
DB of HRA based on Simulator Training Data	Human Performance Data of the Plant Operators [8]	2016

For the 'HELP' function, the frequently used keyword must be selected. And the modification of keywords selected for future use should be applied.

For the technical aspects, the latest IT technologies related to the database need to be checked. For document types, HTML types and XTML types are considered as descriptive content. And for the implementation tool, Visual Basic and Python are considered.

Based on these various considerations, the implementation of a Level 3 PSA-supported database is

under way. More specifically, the conversion to editable files of key documents was completed. And the keyword selection in document file is in progress. Follow-up steps, such as parsing within a description file, checking tags in an XML or HTML file, will be processed step by step.

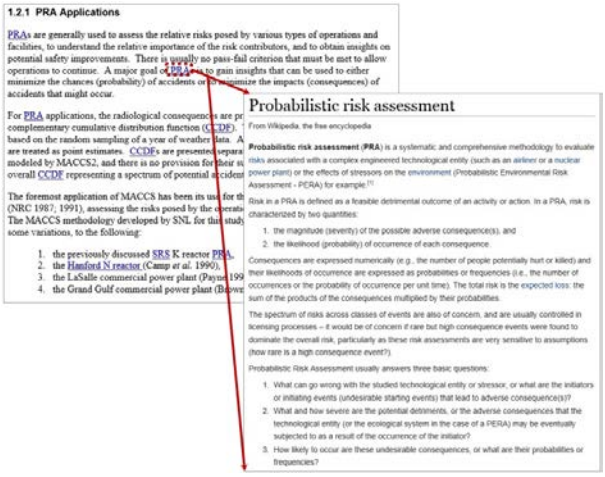

Fig. 1. An example of supporting database

3. Conclusions

According to the scope and the purpose of the data utilization, the construction processes of the database and the contents contained in the database are different case by case. Moreover, in some cases, there are some requisites to produce results such as accident scenarios and accident characteristics. Considering the diversity of database, it needs to specify the database for Level-3 PSA.

Through these studies on databases related to the nuclear safety issues, previously constructed database systems were reviewed and compared. The supporting database focused on building a database for Level 3 PSA code users.

To construct an effective and useful database, in conjunction with the developing Level-3 code, these reviewed requirements will be applied in database construction. With this, the Level-3 PSA documents assembled in a various method can be accumulated later in database. It can be used as an effective data, and used to support the Level-3 PSA code user.

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