A Study on the Design Requirement for the Level 3 PSA Code Development

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INTRODUCTION

The Korea Atomic Energy Research Institute (KAERI) has been starting the code development for the Korean specific level 3 PSA under a National Nuclear R&D Program. First, a technical roadmap for level 3 PSA code development was constructed. As the next step, the design requirements were investigated and studied. In this step, many specifications are included, such as the general requirements, functionality, performance, property, interface, and results. This paper shows the investigated results of the design requirements for the Korean specific level 3 PSA.

KOREAN SPECIFIC LEVEL 3 PSA CODE

The level 3 PSA is an assessment of the off-site consequence analysis of an accidental release of radionuclides in a nuclear facility during operation. However, because the execution of a level 3 PSA is complicated and massive, the calculation is processed through a code (computer program) execution. In this section, the necessity for the development of a Korean specific level 3 PSA code and the related circumstances are reviewed.

Background and Current Status

Based on the lessons from the Fukushima accident, not only is a level 3 PSA execution needed, so is a more detailed analysis of the plant-specific characteristics and site-specific environments. A reflection regarding the newest trends after the Fukushima accident is required, such as the progression of the atmosphere diffusion, or analysis technology or the influences of environmental radiation.

The level 3 PSA model also needs to be improved through the newest technologies. In addition according to the nuclear safety law, a PSA execution is necessary. Owing to the increase in social requirements according to the environmental influences, an assessment of the environmental influences of radiation is needed. Moreover, in the nuclear industry, a technological guarantee of the level 3 PSA fields is necessary.

The international technical trends are described in the report of the IAEA [1]. According to these trends, the level 3 PSA execution and the development of the related technology are progressing in various nations. In particular, the level 3 PSA code is an essential field of level 3 PSA technology, and the code development is progressing.

At KAERI, LADAS for the atmosphere diffusion model and LORAS for the ocean diffusion model were developed, applied for the Fukushima accident assessment, and verified. At KINS, the AtomCARE system (emergency disaster prevention system) was developed, and research into its improvement is ongoing. In addition, the INDAC code for a radiological dose assessment was developed, and its functional complement is progressing. In industries in Korea, a few companies around KHNP are accumulating the execution experience of the level 3 PSA for domestic nuclear power plant.

In the USA, EU, and Japan, level 3 PSA codes were developed by considering the characteristics of the geographical environment. In the USNRC, the CRAC code was developed for a level 3 PSA, and grew into the MACCS2 code in SNL. Recently, its Windows version (WinMACCS) was developed. Countries that do not have their own code have been utilizing the MACCS2 code.

In Japan, the OSCAAR code was developed [2]. For this reason, the source technology of a level 3 PSA was secured, as was the original technology of a few models. In the EU, COSYMA code was developed based on a few codes developed in England and Germany.

In Korea, only the MACCS2 code is used for a level 3 PSA execution code. The relational fields for the level 3 PSA code development, such as the technology of the atmosphere and ocean diffusion model, and the technology of exposed radials, can be utilized for the level 3 PSA code development.

Functional Specification

In Korea, the basic individual technologies of relational fields have been studied and visualized for some models [3]. But it cannot be reached to the integrated technology for the level 3 PSA code development. The security of technology integrating the individual technology for the development of the Korean specific level 3 PSA code is needed. In a recent document [4], the 5 major models were reviewed:

- Diffusion model
- Exposed radial dose model
- Exposed channel model
- Emergency prepared model
- Health influential model

In addition, an economical assessment model is also reviewed, and their comparison is processed.

Technical Classification and Model

To develop a level 3 PSA code, there are many considerations for the technical aspects. In terms of physical models, in addition to the general characteristics, the domestic specifics should be considered. The interfaces of the physical models should also be constructed. In the previous document, the technical fields were classified, and the detailed technical contents were led.

The classification of technical fields are as following:

- Preprocessors aspect
- Code essential aspect
- Second processor aspect
- Code validation aspect
- Documentation aspect
- Management aspect of development

Among these aspects, namely, preprocessors, essential codes, and a second processor, are closely related with their processors and models.

In terms of the preprocessors, many data transactions are developed. The transactions of data are as follows: source term data, atmospheric data, geometrical data, population data, agricultural/economical data, traffic data, emergency preparedness data, radial security data, exposed radial dose data, intake data, and health/nutrition data.

In terms of the essential codes, the developmental environment, core structure, and calculation model are included. In the developmental environment, hardware, software, and debugging environments are basic elements. The code installation, and the production of the release version for each step should be included. In the core structure, input data processing module, sampling module, sample calculation module, result calculation module, and output data processing module are included. In the calculation model, the source term model, diffusion/deposition model, emergency preparedness model, referential/cohort model, exposed channel model, health influential model, and economical loss assessment model are also included.

In second processor aspect, most of the calculation controls are processed according to the user's strategy. Besides these, computing environments for development are investigated for the later upgrades and user conveniences as well as its development.

Approach about the Validation

In terms of the validation, the functional verification, and the results of the calculation are included. For the actual application, the individual verification/validation and the integrated verification/validation should be included. In addition third party independent verification/validation by the outside experts should also be included.

With the code development, a method of verification and validation should be developed at the same time. To do so, examples need to be developed. Through these processes, the verification and validation technologies should be secured.

In terms of the documentation, in addition to the technical documents, a user manual and reference materials including the validation of the calculation model should be produced.

RESULTS AND CONCLUSION

According to these analysis, the detailed technical documents will be described definitely, and official documents per each step are produced also as technical report. The subsequent specifications will be produced, and connected to implementation as a computer program. This will be a Korean specific level 3 PSA code, utilized in level 3 PSA for Korean site.

ENDNOTES

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