An Investigation of Quality Assurance Process to Apply a Computer Program Development of Level 3 (Off-site Consequence Analysis) Probabilistic Safety Assessment

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1. Introduction

The Korea Atomic Energy Research Institute (KAERI) has been starting the code development for the Korean specific level 3 Probabilistic Safety Assessment (PSA) under a National Nuclear R&D Program. Level 3 PSA code Quality Assurance (QA) activities are performed as a part of PSA.

Quality Assurance Manual (QAM) and Quality Assurance Procedure (QAP) are developed for the PSA, which are based on ASME NQA-1-2000, ISO 9001:2008 and KS Q ISO 9001:2009 [1]. This paper presents an investigation of quality assurance (QA) process based on the aforementioned QAM and QAP to apply a computer program development of Level 3 PSA.

2. Level 3 PSA Code and QA application

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.

2.1 Background for code development

KAERI is participating in Nuclear Research & Development (R&D) Program of the National Research Foundation grant funded by the Ministry of Science and ICT. 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.

A technical roadmap for level 3 PSA code development has been constructed. 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 [2]. 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 [3]. 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 radiations, can be utilized for the level 3 PSA code development.

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

2.2 QA application

Related the software development, in RES (Risk and Environmental Safety) department of KAERI, it have been applied the QA since 2010. And the project of level 3 PSA code development belonging to this department is being applied this QA system.

QAM and QAP are developed based on the ASME NQA-1-2000. ASME NQA-1-2000 is composed with 18 requirements. The QA 18 requirements in ASME NQA-1-200 are presented in Table Ⅰ.

Table Ⅰ: ASME NQA-1-2000 Requirements

No	Requirements	Applicable
1	Organization	√
2	Quality Assurance Program	√
3	Design Control	√
4	Procurement Document Control	√
5	Instruction, Procedures and Drawings	√
6	Document Control	√
7	Control of Purchased Items and Services	√
8	Identification and Control of Items	N/A
9	Control of Special Processes	N/A
10	Inspections	N/A
11	Test Control	√
12	Control of Measuring & Test Equipment	N/A
13	Handling, Shipping & Storage	N/A
14	Inspection, Testing & Operation Status	N/A
15	Control of Nonconforming Items	√
16	Corrective Action	√
17	Quality Assurance Records	√
18	Quality Assurance Audts	√

The goals of QAM are using resources effectively and efficiently, ensuring that the level of quality necessary to achieve the requirements and objectives, and ensuring that sufficient documentation is maintained to describe achievements of the require objectives. Several requirements of ASME NQA-1-2000 have been identified as having limitation depending on the R&D category. Applicable requirements, QAM and QAP can be revised on request of project’s characteristics and its participants.

The QAP for software development in RES department of KAERI, was setup in 2004 at first and continuously revised. The phases and its document of software development are show in table Ⅱ.

QA has been improved, and achieved efficiency by performing QAP. The project’s participant’s opinions are necessary to reflect in QAM, QAP and QA activities. It is continuously incurring the revision of QAM and QAP, and QA level of R&D in RES department has affected accordingly.

The completed QA records (originals) are safekeeping in RES department. And later, the important QA records can be transferred the control into the library in Technical Information Team. Meanwhile, in KAERI ANSIM (Advanced Nuclear Safety Information Management) system, the electronic approval system has been implemented for QA management. As a part of ANSIM system, QAM, QAP and the records related corrective action or QA audit for RES department have been saved.

Table Ⅱ: Software Development phases and Documents

Phase	SW development phase	Document
1	Design requirement phase	Requirement definition report
2	Design phase	Design description report
3	Implementation phase	Implementation report (or programming file)
4	Consolidation phase	Consolidation Report (If needed)
5	Verification Test phase	Test plan and results report
6	Installation, checkout and acceptance rest phase	Installation, checkout and acceptance report
7	Software verification & validation phase	Verification & validation report

3. Conclusions

From the investigation of the QA process (QAM and QAP in KAERI), key productions of the code development was identified as technical reports described in Table II. To successfully achieve a QA for the development of Level 3 PSA code, these insights will be applied in the development.

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