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〈Technical Note〉

Development of Database and QA Systems for Post Closure Performance Assessment on A Potential HLW Repository

Y S Hwang, S G Kim, and C H Kang
Korea Atomic Energy Research Institute
150 Dukjin-dong, Yuseung-gu, Daejon 305-353, Korea
yshwang@kaeri.re.kr

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Abstract

In TSPA of long-term post closure radiological safety on permanent disposal of HLW in Korea, appropriate management of input and output data through QA is necessary. The robust QA system is developed using the T2R3 principles applicable for five major steps in R&D' s. The proposed system is implemented in the web-based system so that all participants in TSPA are able to access the system. In addition, the internet based input database for TSPA is developed. Currently data from literature surveys, domestic laboratory and field experiments as well as expert elicitation are applied for TSPA.

Key Words : HLW disposal, total system performance assessment, data management; quality assurance

1. Introduction

In performance assessment, data from inventories, solubility limits and distribution coefficients of species in pore water in a bentonite buffer and rocks, porosities, diffusion coefficients, information on groundwater migration, biosphere, and etc are required. In many cases these data come from experts in different institutes. Sometimes, many data can lose detailed conditions essential for proper interpretation later. Therefore, it is necessary to develop and apply the QA(Quality Assurance) system to keep all records of the data.

Many internationally recognized QA systems are studied. Based on the study, five principles of QA, named as T2R3 [1] are identified. T2R3 has been applied by SNL(Sandia National Laboratory) at the final stage of the WIPP(Waste Isolation Pilot Plant) project for CCA(Compliance Certification Application). Before the concept of T2R3 (Traceability, Transparency, Reviews, Reproducibility, and Retrievability), were applied, quality of many key experiment as well as assessment data was questioned by regulators and general public.

However, after introduction of the QA system based on the T2R3, the CCA was finally approved by the US EPA(Environmental Protection Agency). In addition to the QA system by SNL, other internationally recognized systems are reviewed. Among them, the QA system under US 10CFR 50 [2] is chosen with the SNL system for the platform for system development applicable for TSPA(Total System Performance Assessment) R&D in Korea. The original eighteen QAP' s(Quality Assurance Procedures) which also applied in the SNL QA system, are regrouped suitable for the R&D in HLW(High Level radioactive Waste) disposal. In the WIPP project, all the QA work was recorded on papers.

The newly developed QAP' s by KAERI(Korea Atomic Energy Research Institute) uses the web-based environment. In addition, some code and experiment specific forms to record results from TSPA works have been developed. These QAP' s are applied to a certain R&D areas such as publication of papers and reports and exchange of data among R&D teams.

The management of input data for TSPA is the role of the newly developed database program, PAID(Performance Assessment Input Database). It is based on the web technology combining ASP(Active Server Pages) and HTML(Hyper Text Markup Language) with database softwares. Data are categorized into six areas such as inventories, near field, far field, biosphere, physical constant, and computational record. Recording of data is possible through direct log into pop up windows or a database itself.

Qualified and well-managed data will be used for PSA(Probabilistic Safety Assessment) on a generic repository to dispose of HLW in the near future.

2. Input Database for Tapa

KAERI has developed the disposal concept for permanent disposal of HLW in Korea. To assure the safety of the proposed repository is the one of prime concerns of the research and development. TSPA was proposed to measure the safety of the system. TSPA is composed of many tasks; FEP' s(Features, Events, and Processes) identification, construction of scenarios, development of an assessment method flow chart, development of adequate mathematical models and corresponding computational codes, preparation of input data sets, documentation, and internal and external review.

To prepare data for TSPA, literature surveys and laboratory and field experiments have been performed. Since many of data sets will be continuously used in the future among many concerned parties, transparent management of data sets such as mean values, probabilistic density functions, names of recorders, date of collection should be stored in well maintained places. Traditionally, they were recorded in papers and stored in a special room for further use and audit. However, thanks to the development of internet, data collected from many aspects of R&D' s can be logged into a centralized database without any difficulty. The family of PRAMMAN(PaRAMeter MANagement) and associated softwares were applied in the WIPP project in the United States is the one good example.

KAERI has developed the internet based input data base applicable for TSPA. Users log into the database protected by the password. Users can select six different categories of data classified by physical systems; source, near field, far field, physical constants, and biosphere. In addition, there is another category of calculated data coming from major computational results. To store computation data such as block sizes of input and output files as well as key assessment results into the PAID, the method to deliver data from CMS(Configuration Management System)

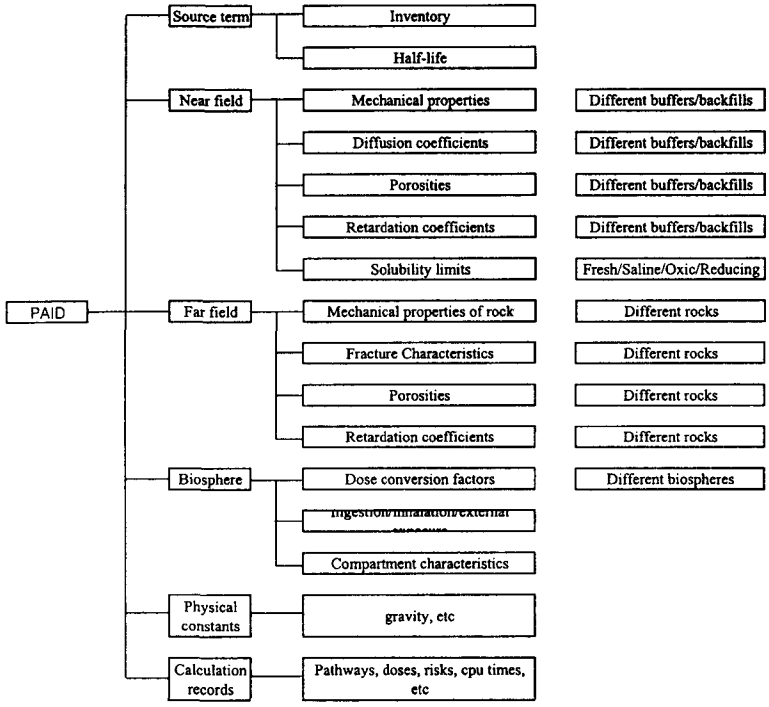

Fig. 1. Entry Window of the PAID Program

softwares such as CVS(Concurrent Versions System) program to the PAID will be developed in the future. Figure 1 illustrates the structure of data. By clicking radio buttons, users move to the next page. Based on this classification, the new relational database in association with MS access, ASP, and HTML is developed.

Data is stored into the database either from the appropriate window as shown in Figure 2 or directly from the MS Access database. As illustrated Material ID and Material Property are used to distinguish a specific data from others. For example, sorption data of Cs-135 in crystalline rock of the Bulkook area is stored in the following manner. The first category belongs to far field so that one is expected to click the button for the far field after log in. Then the next category is Bulkook granite noted as its Material ID. When the material ID is chosen, then it pops up the list of material properties. In this case sorption data of all recorded nuclides are listed on the screen. When specific nuclide is selected, all recorded information of that nuclides such as zero, fifty, hundred percentiles are listed. When multiple nuclides are selected, the summary information of selected nuclides, the value of the fifty percentile, is listed. If the output is exported, it generates the Excel spread sheet.

3. Web Based QA System

In early stage of radioactive waste disposal programs such as the WIPP in the United States, the importance of QA was not recognized. In the middle of the program, many key issues related to QA of data sets, methodologies, etc were emerged. By trial and error, proper QA systems were introduced. Fortunately, some of the existing

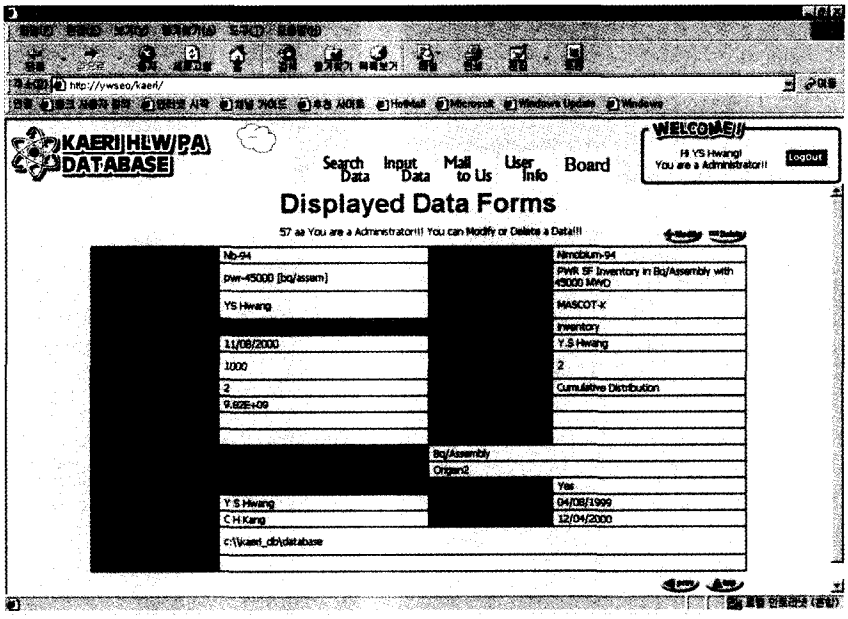

Fig. 2. Displayed Data Form

data were qualified by special arrangement of QED(Quality assurance on Existing Data). Still, many useful data were lost due to the lack of records. KAERI acknowledges the importance of QA from the stage of early R&D works.

Throughout its own R&D and the joint work with the SNL [1] developer of the QA system for the WIPP, principles of the T2R3, are introduced in the five different levels of R&D: (1) planning, (2) research, (3) documentation, (4) internal review, and (5) future independent peer review.

To set up the optimum QA procedures, many internationally well known QA systems were reviewed. The followings are the names and synopsis of the QA system identified by KAERI for the R&D on the permanent radioactive waste disposal.

(1) ISO 9001 : 2000; Model for QA in design, development, production, installation and servicing especially purchasing is identical to TSPA [3],

(2) ISO 9000-3 Guidelines for the application of ISO 9001 to the development, supply and management of software [3],

(3) American National Standard Institute (ANSI) Nuclear Quality Assurance Series
- NQA-1/2; QA program requirements for nuclear facilities and facility application [4],
- NQA-3; QA program requirements for the collection of scientific and technical information for site characterization of high-level nuclear waste repository [5],

(4) Guidance from the Nuclear Energy Agency (NEA) : model verification and validation, peer review for confidence building [6];

(5) Guidance from the IAEA: model verification and validation and general software management [7],

(6) Guidance from the US NRC: off-the-shelf software and software developed outside the necessary QA program to be qualified for use by conducting and documenting test cases [8],

(7) Guidance from the US EPA 40CFR194, [9]

(8) Recommendation by USDOE related to confidence building in TSPA for LLW, which is applicable to deep repositories [3],
(9) 10CFR63 (Draft) : modification of the requirements of 10CFR60 to apply specifically to the Yucca Mountain site with changes on the post-closure performance objective to one using an individual dose limit based on EPA standards.
(10) 10CFR50 : basis for the QA program defining the 18 QA Criteria for which the national standard NQA-1 was issued by the ASME.
(11) 10CFR60 : the regulatory basis for conducting the site characterization program and for complying with the NWPAA(Nuclear Waste Policy Act as Amended) [10].
(12) 10CFR960 : developed in accordance with the requirements of Section 112(a) of the Nuclear Waste Policy Act of 1982 for use by the Secretary of Energy in evaluating the suitability of sites for the development of repositories
(13) 40CFR191 : public radiation doses for nuclear waste disposal facilities [11].

The Appendix B of 10CFR50 in the United States is the starting point. There are eighteen chapters in the code directly related to QA from organizations to audit. To optimize them for the work on radioactive disposal, thorough restructuring was pursued by the SNL. They are re-groups as a set of QAP' s. These QAP' s were used as the cornerstone for KAERI. To develop the system fit for KAERI, KAERI defines the work domains for QA application as:

(1) Laboratory experiments and computational results used to produce papers for academic journals, proceedings, official presentations, technical and research reports and
(2) Exchange of information among different departments inside KAERI

In R&D' s of radioactive disposal, as shown in Figure 3, five major steps are important, (1) adequate planning, (2) controlled execution, (3) complete documentation, (4) thorough review, and (5) independent oversight. Also five principles, T2R3 shown in Figure 4 on QA should be

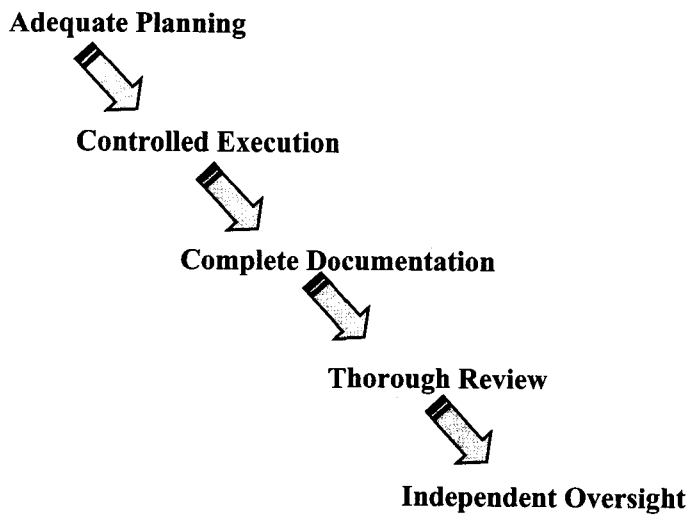

Fig. 3. Five Major Steps in R&D on Radioactive Waste Disposal

considered:

Traceability means that all needed documents inclusive of data can be reached whenever requested. It is applied for all five steps of the R&D, from the stage of planning to reviews through execution and documentation. All the works are to be planned and documented so that needed documents can be available. Transparency is applied for decision making of HLW disposal. It is a key step not only for licensing application but also for public acceptance. It is applied for four steps related with decision making, except for documentation. Review means activities associated with checking the results of TSPA and outcomes of audit processes. Reproducibility means results of TSPA can be reconstructed using the methods documented through QA implementation.

Results from execution of R&D' s, documentation, internal and external audits should be reproduced. For example, if the same codes with same input data sets and computer equipment with same memory chips, hard disks, operating systems, are used for a specific problem, the identical numbers for a given problem should be produced, no matter who is solving the problem. To see the reproducibility in some cases, all the information on CPU times, memory block sizes of input and output files are stored for future check. Finally, retrievability is assuring objectiveness of the whole procedure.

From the planning stage, TSPA with QA is important. As explained, TSPA is an iterative process. In identifying R&D activities for the next step, proper prioritization is needed. For example, if both the effect of a certain parameter on the overall risk and its parameter value uncertainty are large according to the R&D in the previous phase, then profound R&D to reduce the uncertainty in parameter values should be considered for the next R&D. Therefore, from the initial stage of planning thorough QA system is to be applied.

The current version of the web based system by KAERI will be expanded later. At the moment, some QAP are not applicable for these categories of work so that they are at the stage of inactiveness for the time being. However, considering future expansion, all needed QAP are set up for five steps of R&D as shown in Figure 5.

As shown in Figure 6, through the joint work

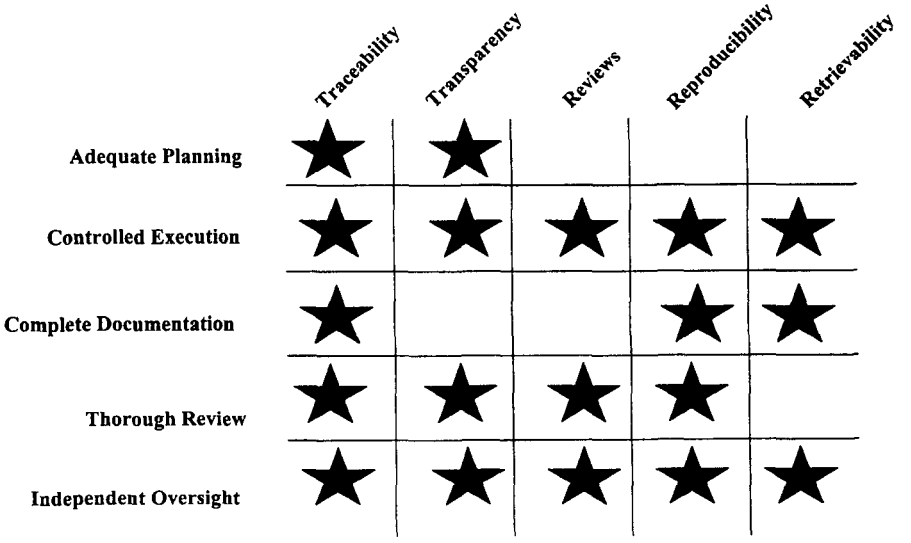

Fig. 4. T2R3 Applied for Implementation of R&D on Radioactive Waste Disposal

QAIP Structure and Relationships

Planning Work	Controlled Execution of Work	Review Work	Document Work Performed	Oversight and Correction
QAIP 1-2	QAIP 6-1	**QAIP 6-3**	**QAIP 17-1**	AP-16.1Q
	QAIP 2-4		*QAIP 17-2*	AP-16.2Q
QAIP 1-5	*QAIP 4-1*		QAIP 6-2	YAP-15.1Q
QAIP 2-5	*QAIP 12-1*			
QAIP 5-1	*QAIP 19-1*			
QAIP 20-1	QAIP 19-2			
QAIP 20-2	*QAIP 20-3*			

Bold	**Used regularly by all staff.**
Italic	**Frequently used in technical work.**
Underline	**May be needed for technical work.**
Shadow	**Rarely used by technical staff.**

Fig. 5. KAERI' s QAP for Five R&D Steps

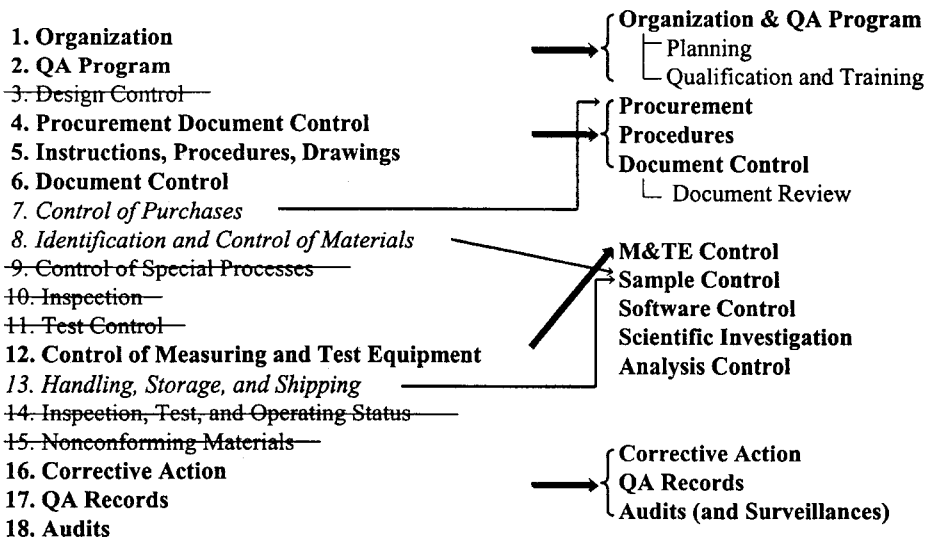

Fig. 6. Regrouping of QAP' s in 10CFR50

with Sandia National Laboratory [1], the original eighteen QAP' s in 10CFR50 Appendix B are regrouped to meet the specific demands from R&D on HLW disposal.

For each category, appropriate QAP' s are developed as illustrated in Figure 7. In addition to the QAP' s, specific forms to actually manage data from experiments and assessment are needed.

Specific experimental forms to record hydraulic conductivities and diffusion coefficients as well as software running record forms for ABAQUS, CONNECTFLOW, MASCOT-K as shown in Figure 8 are created by the HTML language in association with databases by ASP. The new web based QA program is under test to find out the easiness in accessing, recording, document reviewing, etc.

4. Conclusions

To assure the quality and transparency of TSPA, two related systems, QA and input data management systems are developed. To develop the QA systems, key principles are identified from case studies. The T2R3 concept turns out to be the solution to overcome many impending issues on data credibility raised by US EPA, nuclear activists, and concerned local governments throughout the WIPP license process, CCA.

Also, it is applied to the project management and R&D' s on the YMP. To avoid dispute on the validity of data even from the early stage of R&D it is recommended to implement the appropriate QA system based on the concept of T2R3. For each step in planning, execution, documentation, and internal and external reviews, a certain QAP' s are applied. To upgrade the quality of technical papers and reports as well as information management among R&D team members, the newly developed web-based program will be applied. In parallel, the web based input database for TSPA, PAID, is developed. It is designed to store data from inventories, near- and far-fields, biosphere, physical constants, and computational results. The work on PSA to check the viability of a Korean reference disposal concept will depend on these two systems.

Acknowledgement

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