Quality Management System Proposed to JENDL Evaluation Project

Journal of the Korean Physical Society, Vol. 59, No. 2, August 2011, pp. 1298∼1302

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(Received 26 April 2010)

A concept of the quality management system proposed for the Japanese Evaluated Nuclear Data Library (JENDL) is described. The concept is based on the process approach established as an International Standard of a quality management system (ISO 9001). In order to discuss how to guarantee the quality of JENDL, a working group focusing on a quality assurance strategy was established in the Japanese Nuclear Data Committee. After three years of discussions, the working group published a report about a quality management system for JENDL and proposed this work to the JENDL evaluation group of the Japan Atomic Energy Agency. The concept of quality management system of JENDL consists of five items: (1) Objective, (2) Organization, (3) Scope, (4) Quality Assurance, and (5) Quality Manual. The concept of the quality management system and the documented procedure have been presented.

PACS numbers: 29.85.+c, 29.40.+d
Keywords: Nuclear data, Quality management system, Quality assurance, Accountability, Transparency, JENDL
DOI: 10.3938/jkps.59.1298

I. INTRODUCTION

Evaluated nuclear data form an essential part in the accountability of nuclear safety because the reliability of nuclear technology in general highly depends on the quality of design methods and adopted data. From the viewpoint of nuclear knowledge management, it is also important to keep archival records, both on the technical content of evaluation process and descriptions of the evaluated nuclear data for the future generation.

A working group focusing on a quality assurance strategy was established in the Japanese Nuclear Data Committee (JNDC) in FY2006, in order to discuss how to guarantee the quality of the Japanese Evaluated Nuclear Data Library (JENDL) [1]. In the working group, we mainly focused on a "process approach", in which various processes, such as evaluation, validation, and the relationship among these processes play a role. This is based on a concept established as an International Standard of a quality management system (ISO 9001) [2].

An advantage of the process approach is the ongoing control that is provides over the linkage between the individual processes within the system, as well as over their combination and interaction. The processes and their relationship in the evaluation scheme of nuclear data are shown in Fig. 1.

After three years of discussions, the working group published a report [3] about a quality management system for JENDL and proposed this work to the JENDL evaluation group of the Japan Atomic Energy Agency

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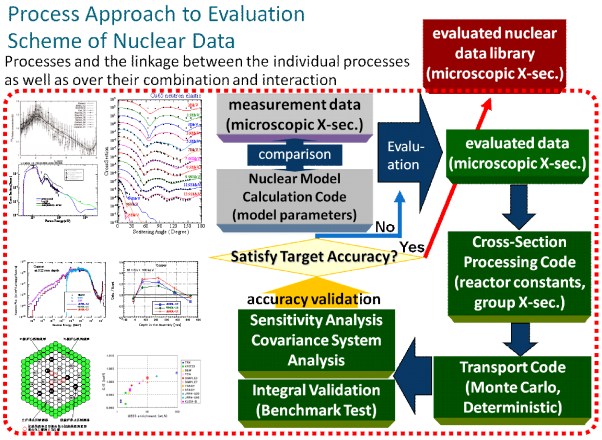

Fig. 1. (Color online) Processes and their relationship in the evaluation scheme of nuclear data.

(JAEA).

The aim of the proposal is to identify the processes required for the quality management system, as well as their implementation and application throughout the organization, and to determine criteria and methods to ensure that the quality assurance processes are effectively used in the organization, as well as effectively controlled and supervised. The concept is useful to enhance traceability of evaluated nuclear data, and to improve their transparency and reliability.

In this paper, the concept of the quality management system proposed for the evaluated nuclear data of JENDL is described.

II. DESCRIPTION OF QUALITY MANAGEMENT SYSTEM OF JENDL

The concept of quality management system of JENDL consists of five items: (1) Objective, (2) Organization, (3) Scope, (4) Quality Assurance, and (5) Quality Manual.

1. Objective

The objective is "identifying the processes of the evaluation method, as well as to establish a documented procedure with respect to the evaluation and validation scheme for evaluated nuclear data (JENDL), and to ensure the quality of the evaluated nuclear data based on the validation of the accuracy of the data."

2. Organization

The organization consists of the JENDL evaluation group of JAEA and members of JNDC who take part in evaluation, compilation and validation of the JENDL data. The organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness.

3. Scope

The scope is the evaluation, compilation and validation of the JENDL as a software product in conformity with the requirements of International Standard, ISO 9001:2008. Exclusions are 1) management responsibility, 2) purchasing, and 3) measurement that do not affect the quality of evaluated nuclear data (JENDL).

4. Quality Assurance

The quality assurance is determined to have following requirements:

(1) Establish a quality management system vis-a-vis quality assurance of JENDL.

- identify the processes needed for the quality management system and determine the sequence and interaction of these processes and their application throughout the organization
- determine criteria and methods needed to ensure that both the operation and control of these processes are effective,
- ensure the availability of resources and information necessary to support the operation and monitoring of these processes
- implement actions necessary to achieve planned results and continual improvement of these processes,
- determine method of internal audit, corrective and preventing actions for nonconformity, and continual improvement of the effectiveness of the quality management system.

(2) The JENDL evaluation group shall manage the following documentation in conformity with the quality management system defined above.

- documented statements of the quality policy and quality objectives,
- a quality manual,
- documented procedures in conformity with ISO 9001:2008,
- documents needed by the organization to ensure the effective planning, operation and control of its processes,
- records and control of records.

(3) The JENDL evaluation group shall report the method of internal audit, corrective and preventing actions for nonconformity, and the continual improvement to JNDC at scheduled regular intervals. JNDC reviews the quality management system for the JENDL data.

(4) The method of internal audit should be structured in a way that is both effective and reliable and does not decrease research performance.

5. Quality Manual

The quality manual should contain a quality policy, quality objectives, the scope of the quality management system including any exclusions, procedures established for the quality management system and a description of the interaction between the processes.

Documents required by the quality management system should be controlled, and documented procedure and adopted data should be recorded for both evaluation and validation processes. The changes and the current revision status of documents are also identified. For the evaluation process, adopted data and method including model parameters should be recorded by each MF section of the ENDF-6 format [4]. For the integral validation process, adopted method and data including selection criteria and accuracy for benchmarks should be documented.

A. Quality Policy

Quality management system is established and operated to assure the quality of the evaluated nuclear data library, JENDL. The quality of the JENDL evaluated data, and the evaluation processes, are assured by adherence to responsibilities ensuring transparency and traceability.

B. Quality Objective

The quality of JENDL is assured based on the validation of accuracy of the evaluated nuclear data and the documented procedures of the JENDL evaluation method and the evaluation processes.

C. Scope

The scope is evaluation, compilation and validation of JENDL as a software product in conformity with the requirements of ISO 9001:2008. Exclusions are 1) management responsibility, 2) purchasing, and 3) measurement that do not affect the quality of the JENDL data.

D. Processes and interactions of these processes

JENDL evaluation processes are shown in Fig. 2.

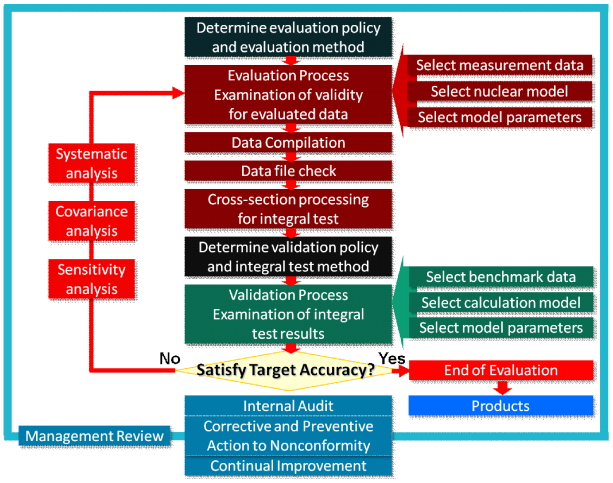

Fig. 2. (Color online) JENDL evaluation processes.

III. RECORDS AND CONTROL OF RECORDS

1. Procedure of Documentation

Responsible person(s) are assigned as document manager(s) for each isotope or working process. The person is not necessarily in charge as a representative of the evaluation or validation. There may be just one person, if (s)he can manage all isotopes and/or validations. Evaluators have to submit technical information regarding the evaluation and/or validation results to the document manager.

The document manager issues a document identification (ID) number and informs the evaluator of the document ID. The document manager puts the ID number into the document header and adds it to the document management list. The format is determined separately.

In order to classify document contents by ID number, the following nomenclature is effective. For example, a resonance parameter evaluation of ^{235}U for JENDL-4 revision 1, named "J4_ev_2_r1_922350_mf[2]_mt[151]" indicates report No. 2. For example, for an integral test, "J4_it_3_r2_cp[mcnp5]_bn[ICSBEP-LEU-SOL-THERM-004-001]" indicates report No. 3 for the ICSBEP criticality benchmark [5]: ICSBEP-LEU-SOL-THERM-004-001, using the mcnp5 [6] code, and JENDL-4 revision 2. In the case of cross-section processing, "J4_lp_4_r3_za[922350]" means report No. 4 of point-wise/group-wise cross-section generation of ^{235}U for JENDL-4 revision 3. In the case of handout material for the JNDC working group, "JNDC_mm_QAWG_20090401_1" means minutes 1 of quality assurance strategy meeting at April 1, 2009. Any database software can be adopted as the document management system.

2. Record Contents

The following records are required from the point of view of quality assurance of nuclear data. These are classified into evaluation and integral validation.

A. Evaluation

Descriptions of the evaluation policy and the adopted methods for cross-section evaluations are necessary as follows: (1) an important notice on the evaluation and a description of the adopted method for each reaction, in each range of energy and angle. If the adopted method is different for each reaction and/or energy range, the reason should be documented, (2) the experimental data adopted for each reaction, range of energy and angle, (3) the cross-section calculation code (name, version number

including modifications if applicable) and the adopted model parameters, and (4) in the case that the evaluation value is changed, modified or adjusted, the reason of modification or adjustment. The following descriptions are also required.

- Details

Contents described in the MF1 of ENDF-6 format: reasons for revision if revision is done, the evaluation scheme and procedure, and references and data lists that describe the history of previous evaluations, in an understandable way.

- MF = 1

Adopted experimental data, range of energy and angle, reasons for adoption, the evaluation method and the procedure, conditions of the methods, references, and comment on important items.

- MF = 2

In addition to the MF = 1 contents, selection reason of energy range for resolved and unresolved resonance parameters, the adopted code, and selection criteria for model parameters.

- MF = 3

In addition to the MF = 1 contents, reasons for the model selection, the adopted model parameters such as optical model parameters, level schemes, level density parameters, *etc.* In the case that the average cross section is evaluated based on energy resolution, the reasons of the energy range settings and conditions.

- MF = 4

In addition to the MF = 1 contents, reasons for the model selection and the model parameters, and the reasons for the selected Legendre coefficients and the Legendre order.

- MF = 5

In addition to the MF = 1, reasons for model selection and the model parameters.

- MF = 6

In addition to the MF = 1, reasons for model selection and the model parameters for energy-angle double differential cross sections.

- MF = 7, 8, 12, 13, 14 and 15

In addition to the MF = 1, reasons for model selection and the model parameters, and reasons for the selected energy range.

- MF = 31, 32, 33, 34 and 35

In addition to the MF = 1, reasons for the model selection and the model parameters, and the method for error estimation.

B. Integral Validation

Description of the evaluation policy and adopted method should be added to the integral validation in the following way: (1) an important notice on the validation and a description of adopted methods and benchmarks. If the adopted method is different from each benchmark problem, the reason should be documented, (2) cross-section generation method or adopted cross-section library name, (3) cross-section generation code (name, version including modification) and adopted input data, and (4) validation calculation code (name, version including modification if applicable) and adopted input data. In the case that a sensitivity analysis, and/or a systematic analysis is done, the accuracy and the validation results should be documented. The following descriptions are also necessary.

- Details

The objective of the benchmark should be documented. (For example, "Validation of ^{235}U cross section of JENDL-4 for thermal reactor application")

- Adopted cross-section library

Isotopes, version, date of production and the name of person, forwarding/receiving date and person, media information (ex. Web, CD, DVD, ftp, *etc.*), cross-section generation code (name, version including modification if applicable), processing date and the name of person, operating system, production scheme, input data for processing if available.

- Adopted validation code

Validation code (name, version including modification if applicable), operating system, validation date and name of person, validation scheme, input data and adopted auxiliary codes if used, name of adopted cross-section library.

- Integral test data and/or benchmark data

Integral test data (name, date, version including modification if applicable), details of geometry and experimental conditions The benchmark data for open to public are preferable.

- Validation results and accuracy

Calculation results and the examination, evaluation, discussion and validation for the calculation results, results of sensitivity analysis, covariance error analysis, and systematic analysis if adopted, minutes and documents of validation meeting, review report.

Cross-section processing and validation codes are standard ones for open to public. The latest versions of these codes are used and should be fixed during validation work. Computers, operating system and compilers should also be fixed during the validation work.

Integral test data and benchmark problems should be selected and prepared as a set of "standard integral test data." The set includes input data, scripts, batch files, auxiliary codes, and utility source program if used.

Discussion papers, symposium documents, minutes and memorandums at the evaluation/validation meetings are valuable for improving traceability of adopted data. These materials should also be documented.

When the integral validation is done by using ICSBEP and/or IRPhEP [7] benchmarks, the treatment of the other integral data should be considered in the case that it may be insufficient to cover all validation items by using these benchmarks only.

Regarding shielding integral test, benchmark problems are only available for major nuclides. Benchmark data for minor isotopes are not sufficient to validate the

accuracy of the data.

If integral test data and/or benchmarks not for open to public are adopted in the validation, it should be simply noted and documented the reason.

IV. CONCLUSION

The quality management system proposed for the evaluated nuclear data of JENDL has been described. The philosophy is based on the "process approach" which is established as an International Standard of a quality management system (ISO 9001). The concept of quality management system of JENDL consists of five items: (1) Objective, (2) Organization, (3) Scope, (4) Quality Assurance, and (5) Quality Manual.

The aim of the proposal is to identify the processes required for the quality management system, as well as their implementation and application throughout the organization, and to determine criteria and methods to ensure that the quality assurance processes are effectively used in the organization, as well as effectively controlled and supervised. The proposal is a recommendation to the JENDL evaluation project, and does not mean the requirement on the current version of JENDL.

We expect the internal audit, corrective and preventing actions for nonconformity, and the continual improvement of the JENDL quality management system will be established by the JENDL evaluation group of JAEA and the application will be implemented in the JENDL-4 [8] as quickly as possible.

The concept of the quality management system proposed in this study is useful to enhance traceability of evaluated nuclear data, and to improve their transparency and reliability.

ACKNOWLEDGMENTS

This work has been performed as an activity of Japanese Nuclear Data Committee.

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