Implementation of the Safeguards-By-Design (SBD) for Small Modular Reactors

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1. Introduction

SMART (System-integrated Modular Advanced ReacTor) is a small modular reactor (SMR) developed by Korea Atomic Energy Research Institute (KAERI). It has obtained the world's first standard design approval (SDA) from the Nuclear Safety and Security Commission (NSSC). Pre-project engineering (PPE) [1] with Kingdom of Saudi Arabia (KSA) had been successfully completed and the next actions including standard design change approval (SDCA) [2] to build the FOAK (First-of-a-kind) plant in KSA are now under negotiation.

IAEA (International Atomic Energy Agency) is actively pursuing the development of a safeguards approach to SMRs in preparation for the possibility of nuclear materials being transferred to the country where SMRs are firstly introduced if they are exported. To apply a safeguards approach to SMART facilities, NSSC suggested KAERI to join the task (Safeguards-By-Design for Small Modular Reactors). KINAC (Korea Institute of Nuclear Nonproliferation and Control) was designated to support this task as Technical Support Organization (TSO). Therefore cooperation among KAERI, KINAC, NSSC and IAEA is essential to review the unique design features of SMART and to establish safeguard principles from the initial stage of the design.

In the present paper, a newly launched task regarding implementation of safeguards-by-design (SBD) for SMART facilities will be briefly explained.

2. Details of the task

In this section background of the task is briefly introduced. Then the necessities and objectives of the task are described. Expected outcomes and detailed contents of the task are also provided.

2.1 Background of the task

The IAEA MSSP (Member State Support Program) is a project to support the IAEA outside the IAEA's regular budget through voluntary contributions from member states to implement effective safeguards. This project started in 1977 with the United States joining for the first time. Republic of Korea (ROK) joined this project in 1997 and actively supports and contributes to the IAEA both in cash and in kind. Currently 21 member states are participating in this MSSP.

Recently IAEA proposed a new SP-1, 18/CCA-002 (Safeguards-By-Design for Small Modular Reactor), which was accepted by the NSSC [3]. Earlier this year, ROK held an advisory meeting attended by SMART design experts from the KAERI to apply the concept of SBD at the design stage for SMRs.

The KAERI had submitted the draft version of design information questionnaire (DIQ) and made a revision once reflecting the IAEA and KINAC's review comments. In order to prepare a Safeguards Technical Report (STR) in the future, they all agreed that the existing advisory council is not enough and it is needed to organize and implement the task as a commissioned research.

2.2 The necessities of the task

The SBD principles for SMRs are still in the development stage, and the level of understanding upon the application of the SBD approach to SMRs and the participation from member states are relatively low. SMRs currently being actively developed by many countries, including the United States, Russia, China, Argentina, and the ROK, have different design characteristics. Therefore it is very important to consider a SBD approach from the initial design stage for each type of reactors.

The SBD principles need to be prepared from the initial design stage, reflecting the unique design features of SMART. In order to review the design information and the possible paths of nuclear material movement of SMART which are classified as confidential or non-disclosure, SMART development experts must participate together in the development of a SBD approach to maximize synergy.

2.3 The objectives of the task

The objectives of the task are:

(1) To apply the IAEA's SBD principles to SMRs; the design characteristics of the SMART facility developed by the KAERI are to be verified and a foundation shall be established to ensure that SBD is faithfully implemented from the initial design stage of SMRs.

(2) To identify the technical challenges necessary for implementing SBD principles to SMRs, and to check the SBD application procedures for the design of SMART facilities.
(3) To promote the awareness of the need for SBD among member states and nuclear power plant industries, and to contribute to cooperation between IAEA and member states.
(4) To build a foundation for SBD application in the design of SMART by providing a DIQ and by supporting the documentation of STR.

2.4 Expected Outcomes

By applying the SBD approach to a locally developed SMR as early as possible, it complies with the IAEA's SBD principles and contributes to promoting overseas exports. At the end of the task, SMART will be a model of best practices in applying the SBD approach to SMRs. This task is expected to contribute to successful completion of the development of a SBD approach related to SMART facilities, and also to support preparing STR on SMART facilities. This task will also promote human and material cooperation as necessary, such as exchange of human resources between ROK and the IAEA. Finally contribution to the international community will be enhanced.

2.5 Contents of the task

A. Preparation of Design Information Questionnaire

DIQ is a collection of questions to identify characteristics of the reactor facilities that must be considered in applying safeguards. The KAERI submitted a draft version of DIQ to the IAEA, and the IAEA provided detailed review comments. The KAERI is carrying out the revision of the DIQ by faithfully reflecting the IAEA's review comments. Compared to other member states, the level of preparation of the DIQ for SMRs in ROK is highly advanced. If it is completed as early as possible, it may be utilized as a model example. As the SBD approach can be developed only after the DIQ is completed, it is required to complete the revision work without delay.

Major contents of the DIQ are: general design information, fuel injection and nuclear material handling procedures, fuel design, nuclear material flow and material balance, and facility drawings, etc. The contents and scope of the DIQ should be determined after consultation with the IAEA, KINAC, and KAERI. The confidentiality shall be noted. The finally prepared DIQ is attached to STR.

B. Support for Preparation of Safeguards Technical Report

The safeguards technical report is the final result of the parent task of the present commissioned research. It is used as a reference for IAEA inspectors and is not disclosed to the public unless otherwise specified. It shall describe the legal authority, responsibilities, and related scenarios of importing and exporting countries, especially considering that SMART is pursuing an export. To complete the STR of the parent task, input will be provided for the portion allocated to the KAERI.

Major contents of the STR are: necessity of safeguards in the design stage, legal background and status of IAEA safeguards, introduction of SMART development status and key features, description of SMART's large equipment transport means and entrances, SMART's nuclear material movement paths, etc. The details and scope of the STR should be prepared after consultation with the IAEA, KINAC, and KAERI. The confidentiality shall be noted.

3. Conclusions

A recently assigned task regarding implementation of SBD for SMART facilities was briefly introduced. As results, the revision of the SMART DIQ is expected. It shall be completed as early as possible to faithfully reflect the IAEA's review comments and to improve its completeness and accuracy. By achieving a high degree of completeness of DIQ, it would be a model example for other member states who want to apply the SBD to SMRs. This could not only enhance the IAEA's ability to implement SBD, but also contribute to strengthening the status of the ROK as a member.

To generate the safeguards technical report, input will also be made for the portion allocated to the KAERI. It includes: description of the SBD implementation information so that the concept of safeguards can be secured in the design stage of SMART, information required by the IAEA for the application of safeguards to SMART, comprehensive design information related to safeguards, and so on.

After completing the preparation of the portion of STR allocated to the KAERI, revision is not included during the present task period. Therefore it may be necessary to discuss whether to extend the period of the present task to the next year in order to improve the completeness and accuracy of the draft version of STR for SMART to reflect possible review comments from the IAEA.

ABBREVIATIONS

DIQ	Design Information Questionnaire
FOAK	First-of-a-kind
IAEA	International Atomic Energy Agency
KAERI	Korea Atomic Energy Research Institute
KINAC	Korea Institute of Nuclear Nonproliferation and Control

KSA	Kingdom of Saudi Arabia
MSSP	Member State Support Program
NSSC	Nuclear Safety and Security Commission
PPE	Pre-Project Engineering
ROK	Republic of Korea
SBD	Safeguards By Design
SDA	Standard Design Approval
SDCA	Standard Design Change Approval
SMART	System-integrated Modular Advanced ReacTor
SMR	Small Modular Reactor
STR	Safeguards Technical Report
TSO	Technical Support Organization

REFERENCES

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