

IMPLEMENTATION OF SAFEGUARDS AND SECURITY OF NUCLEAR MATERIALS

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ABSTRACT

The national regulatory of nuclear materials (NM) was performed under Safeguards Agreement (SG) and State's Nuclear Security (NS) regime from May 16, 1974. The concerning international instruments were; 1) Treaty of Non-Proliferation of Nuclear Weapons (NPT); 2) Convention of the Physical Protection of Nuclear Material (CPPNM); and 3) The Resolution of United Nations Security Council 1540 (UNSCR 1540). Some current domestic laws, Act and Proclamation, which follow the State policies and regulations, as well as the present nuclear technology, were accomplished in fiscal year 2016.

The national roles and polices, relating to the roles and policies of the International Atomic Energy Agency (IAEA), are described and all followed these international instruments. The measures for best practice on the NM regulatory of nuclear fuels of 2 MW research reactor and other NM in locations outside facilities (LOF) are summarized. This research reactor, at present, is under the operation and maintenance of Thailand Institute of Technology (Public Organization) or TINT. The nuclear materials accounting and control (NMAC) and Physical protection system (PPS) were performed and modified under the regulatory and the missions of both OAP and TINT.

The IAEA inspectors have annual verification to assure the international community that NM, nuclear facilities (NF), and other items subject to SG are used for peaceful purposes. Under SG, Office of Atoms for Peace (OAP), as the national regulator, has to cooperate with IAEA nuclear safeguards inspectors for annual NM inspection. The life extension programme for this research reactor, as aging management programme (AMP), was set up via TINT from 2011 by technical support of IAEA Expert Mission at the beginning. The author's project, "The application of IT to create NM database to support national NMAC", was at the beginning phase from last fiscal year 2016. This project is expected to serve the increasing of NM utilization in locations outside facilities in the future.

Keywords: Nuclear materials, Safeguards, Nuclear security, Regulatory, Research reactor

1.0 Introduction [1]

1.1 Safeguards (SG) and nuclear security (NS) related to NPT [2, 3, 4, 5, 6, 7]

Thailand was the member of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) from December 7, 1972. Thailand, as the non-nuclear weapon state (NNWS), signed and ratified Safeguards Agreement (SG) with International Atomic Energy Agency (IAEA) on May 16, 1974. Under SG, Thailand was required to establish and maintain a state system of accounting for and control of nuclear materials (SSAC).

Office of Atoms for Peace (OAP), as the national regulator, was assigned to be the responsible group to co-operate with IAEA nuclear safeguards inspectors for annual nuclear materials inspection under SG. The main nuclear material is the spent fuel of 2 MW TINT nuclear research reactor and the others are some nuclear materials in a small amount of some locations outside facility (LOF). Thailand also signed Additional Protocol (AP) related to SG on September 22, 2005 but is in the stage of preparations of declaration.

1.2 Convention of the Physical Protection of Nuclear Material (CPPNM) [6, 7]

States are obliged to protect nuclear material (NM) on their territories and during international transport, at levels specified in the Convention of the Physical Protection of Nuclear Material (CPPNM), i.e.:

- Annex I: Levels of protection by category of NM
- Annex II: Definition of three categories of NM

Moreover, States are not to undertake transport/transits unless NM is protected at the appropriate levels. However, Penalties are required under national law.

Current domestic legislative work which Physical Protection System (PPS) for NM regulatory was applied is “The Proclamation of Office of Atomic Energy for Peace B.E. 2559 (2016): Security procedure for nuclear material and nuclear facilities”. This proclamation was issued on August 02, 2016 and was enforced after September 01, 2016.

1.3 UNSCR 1540 [7]

As one of the United Nations members, Thailand has to follow “The resolution of United Nations Security Council 1540 (Non-Proliferation of Weapons of Mass Destruction)”. It is necessary to set up the nuclear material regulatory system to control the manufacturing of nuclear, chemical, and biological weapons of mass destruction, as well as control of international transit and shipment.

UN Security Council Resolution 1540 requires protection of weapons of mass destruction, i.e.:

- Prohibition of unauthorized persons from engaging in activities with nuclear weapons and materials
- Criminal laws-punish offences
- Accounting for and securing items and materials
- Effective physical protection
- Effective border controls and law enforcement to detect, deter, prevent, and combat illicit trafficking
- Effective import/export regulations

2. Role of the IAEA and the State related to NPT and SG [8, 9, 10, 11]

The vast majority of safeguards agreements are comprehensive safeguards agreements (CSA) that have been concluded by the IAEA with non-nuclear-weapon States (NNWSs) parties to the NPT and nuclear-weapon-free zone treaties. The IAEA has to date concluded comprehensive safeguards agreements with 174 States.

Safeguards are based on assessments of the correctness and completeness of a State's declared nuclear material and nuclear-related activities. Verification measures include on-site inspections, visits, and ongoing monitoring and evaluation.

Thailand, as one of NNWSs, is under the measures of nuclear material accountancy, complemented by containment and surveillance techniques, such as tamper-proof seals and cameras that the IAEA installs at facilities [Fig 1].

IAEA responsible functions:

- Detect any diversion of declared nuclear material in declared facilities or Locations outside Facilities (LOFs)
- Detect any undeclared production or processing of nuclear material in declared facilities or LOFs
- Detect any undeclared nuclear material or activities in the State as a whole

- Through safeguards, the IAEA is able to provide credible assurances that States are honoring their international obligations to use nuclear material only for peaceful purposes.

State responsible functions:

- The inventory of nuclear material
- The changes in that inventory, including receipts into and transfers out of the material balance area
- Correct and complete reports need to be provided to the IAEA in time
- State reports represent the basis for IAEA verification



Fig. 1 SG Regulatory system for nuclear material accountability (NMAC)

The criteria for NMAC establishment:

- National requirements to account for and control nuclear material necessary to regulate nuclear material possession and use (at the State and Facility level)
- International requirements to enable the States with CSA to provide correct and complete nuclear material accounting information to the IAEA that represents the basis for independent IAEA verification

2.3 Some IAEA regulatory concepts for good practices [12]

1) Concerning good practices

- Security measures have to take into account the safety requirements such as accessibility to equipment for the purpose of normal operation, in-service monitoring and maintenance.
 - Measures have to be in place to assure that a safety event is not fabricated as a ruse or diversion for a pending security incident.
 - Physical barriers (or other delay system) need to be able to accommodate, when necessary, a rapid evacuation of or access to site areas in the event of a security event or radiological accident.
 - Some emergency access and egress measures need to be planned so that they do not introduce delays to incoming or evacuating personnel. This could include escorting emergency personnel and keeping evacuating persons into a safe, contained area.

2) Areas subject to potential conflicts between safety and security and strategies for solutions

- Access control
- Information management/management system
- Siting
- Maintenance

- Modifications
- Emergency Preparedness
- Contingency preparedness
- Long shutdown periods

3) *Considerations in the management of changes and modifications*

- The layout of security layers in the facility surrounding security targets, including access controlled points
 - The configuration and purpose of structures, systems, and components important to safety and systems and equipment important to security at the facility
 - Facility operating procedures
 - Security plan and procedures
 - The operating programme of the facility
 - The safety analyses and operating limits and conditions
 - Facility license conditions and licensing process
 - Engineering & maintenance
 - Etc.

3. Implementation of the State on SG/NS

3.1 State policies [13, 14, 15, 16]

From the 6th policy of 11th Thailand National Economic and Social Development Plan, B.E. 2555-2559 (2012-2016), which is the national policy of science, technology and innovation, the atomic energy is required to be developed safely for high competency in competition with other international countries. Office of Atoms for Peace (OAP), takes responsibility in nuclear and radiation regulations, as well as supporting concerning international instruments.

From Thailand 2016-National Progress Report in Nuclear Security Summit 2016, the implementation of nuclear security was performed relating to the state policies, as well as the concerning international instruments, as the following policies/strategies/missions/action plans.

- Strengthening Nuclear and Other Radioactive Material Security
- Minimizing Nuclear and Other Radioactive Materials
- Countering Nuclear Smuggling
- Supporting Multilateral Instruments
- Collaborating with International Organizations
- Partnering with External Stakeholders

On April 01, 2016, Thailand Prime Minister presented his statement in 4th Nuclear Security Summit at Washington D.C., USA, on “*National Actions to Enhance Nuclear Security*”, as the following summaries.

- Issuing the new and updated legislative law and enforcement, relating to the international legal instrument, agreements and treaties for best practice of nuclear security.
- Continuing National Nuclear and radiation Regulatory law improvement for higher efficiency in practice and enforcement following international standards, especially IAEA standards.
- Work accomplished in last year 2015:
 - New proclamations on export and import dual used goods
 - The customs was the legal authority to inspect, check & investigate and hold suspected goods.

- Improvement the co-operation and working procedure between the concerning competent authorities, i.e. border polices, customs, immigration, regulators, and etc. to detect, delay and response the transportation of the suspected goods.
- Knowledge management setup and contribution for concerning organizations in the country, especially border areas where there is the high risk in the cases of the transportation and the illegal immigration of MORC (nuclear material out of regulatory control).
- Upgrading the knowledge and the understanding of the public, including the protection and the emergency response for the safety and security of the people. All the concerning stakeholders, both private and government organizations, are expected to take part in “National Actions to Enhance Nuclear Security”.
- To create the integration of the concerning working procedures and improve the domestic and international co-operations.

3.2 Current State regulations [4, 5, 6, 17]

In October 16, 2015, the Ministry of Commerce issued a new notification on Export Control for Dual-Use Goods requiring permissions for export of items under the updated Dual-Use Goods (DUI) list, which is similar to the one being used by the European Union. This notification is scheduled to take effect on January 01, 2018. The dual-use goods are the goods which can be used for general commercial purposes as well as for military purposes.

At the beginning of August 2016, the updated domestic Act and Proclamation on nuclear material regulatory were legislative enforced relating to SG and NS, as below.

- 1) Nuclear Energy Act, B.E. 2559 (2016), issued on August 01, 2559 (In Thai).
- 2) The Proclamation of Office of Atomic Energy for Peace B.E. 2559 (2016), “Security procedure for nuclear material and nuclear facilities”, issued on August 02, 2559 (In Thai).

Both will enable Thailand to accede to the Convention for the Physical Protection of Nuclear Materials (CPPNM) and its 2005 Amendment. The enforcement affects both nuclear materials (NM) and nuclear facilities (NF). Nuclear facilities here are Thai 2 MW research reactor and, if possible, new small research reactor and nuclear power plant in the future.

Section 4 and section 5 of Nuclear Energy Act, B.E. 2559 (2016) are the requirements for NM and NF regulatory, respectively. They follow CPPNM, especially physical protection system (PPS) for NM and NF. The “3S” (Safety, security, and safeguard) are also required for NF.

From the Proclamation of Office of Atomic Energy for Peace B.E. 2559 (2016), “Security procedure for nuclear material and nuclear facilities”, PPS is required for the protection of malicious acts from theft and sabotage of 3 categories of NM, including cyber security for NM category I. For NF, it is required to have PPS based on “Design basis threat (DBT)”, which was obtained via “Threat assessment (TA)”, as well as Defense-In-Depth (DID) approach for NF cyber security measures.

It includes the following measures relating to physical protection regime.

- To protect against unauthorized removal
- To locate and recover missing nuclear materials
- To protect against sabotage
- To mitigate or minimize effects of sabotage

There also are other concerning nuclear materials regulation laws, as the following.

- 1) Ministerial Regulations for specifying the conditions of license request procedure and the management of special nuclear materials, source materials, by-product materials or atomic energy; B.E. 2550 (2007)
- 2) Atomic Energy Commission for Peace Proclamation on safeguards of nuclear materials non-proliferation; B.E. 2554 (2011)
- 3) Atomic Energy Commission for Peace Proclamations B.E. 2554 (2011) on:
 - a. License forms of nuclear materials and source materials
 - b. Permission period of nuclear materials and source materials license
 - c. Report forms of nuclear materials quantities in possession and in the case of being lost or damaged or being threatened to perform anything else to these nuclear materials
 - d. Transfer of permitted nuclear materials to store at another place, which is not identified in their licenses
 - e. Procedures of radioactive wastes treatment and return

4. Measures for proceeding SG/NS [1, 4, 5, 6, 7]

4.1 NMAC vs PPS [18, 19]

Safeguards (SG) are activities by which the IAEA can verify that a State follows to its international commitments not to use nuclear programmes for nuclear-weapons purposes. The Nuclear Non-Proliferation Treaty (NPT) and other treaties against the spread of nuclear weapons entrust the IAEA as the nuclear inspectorate.

A state system of accounting for and control of nuclear materials was established from 1974 and was maintained up to now. The main task focuses on spent fuel of 2 MW TINT nuclear research reactor. Besides that, there are some nuclear materials in a small amount in some locations outside facility (LOF). Some of them are applied for research and development projects. Most of the rest are depleted Uranium (DU), which are used as radiation shielding.

A physical protection (PP) is designed primarily to prevent access to a nuclear facility and its nuclear material by unauthorized persons (outsiders). Nuclear material accounting and control (NMAC) helps to deter and detect possible removal or misuse of nuclear material by authorized persons (insider). Both systems, NMAC and PP, should be implemented, performed effectively, and executed together as the diagram of Figure 2.

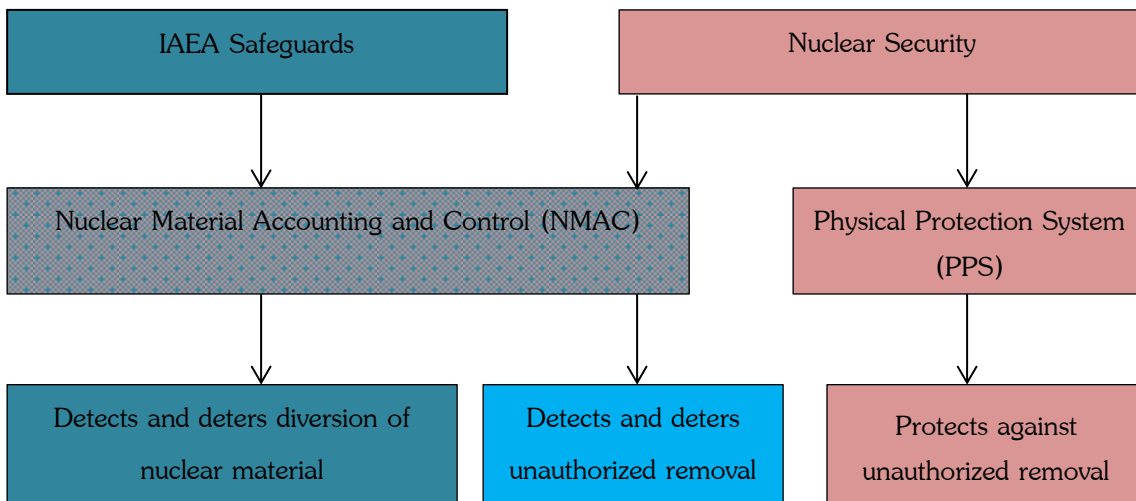


Fig. 2 Relations between NMAC and PPS

The basis nuclear security application for 2 MW RR (TRR-1/M-1) is shown as the following slides of Figure 3 [20].

<p>TINT 2 MW RESEARCH REACTOR SECURITY AREA J. KRATKAEW (BUREAU OF NUCLEAR SAFETY REGULATION, OAP) TINT GOT IAEA ASSISTANCES UNDER THE PROJECT "INTERNATIONAL PHYSICAL PROTECTION ADVISORY SERVICE" (IPPAS MISSION)</p> <p>Access Control</p> <p>1. Guard security control at the entrance at the fence</p> 	<p>2. ENTRANCE DOOR TO REACTOR BUILDING</p> <p>ID ACCESS CARD CONTROL</p> 	<p>BEFORE ENTER REACTOR AREA</p> <p>3. At the entrance to reactor area</p> <ul style="list-style-type: none"> Need permission from control room No smoking Need personal pocket dosimeter No high heel shoes allowed 
<p>TO PROTECT THE CONTAMINATIONS TO YOUR SHOES</p> <p>NEED TO COVER OR CHANGE YOUR SHOES</p> 	<p>WASH YOUR HANDS AFTER EXIT FROM RR AREA</p> 	<p>DETECTION AREA (VDO SURVEILLANCE - OR SOME SENSORS)</p> 
<p>DELAY AREA NEED TO WALK UP THE LADDER (APP. 10-15 METERS) TO THE REACTOR POND</p> 	<p>DELAY AREA (INSIDE THE CONTAINMENT)</p> 	<p>THAI RESEARCH REACTOR MODIFICATION 1 (TRR-1/M 1: TRIGA MARK III)</p> 
<p>RESEARCH REACTOR CONTROL ROOM</p> 	<p>SPENT FUEL STORAGE (UNDER THE WATER IN THE POND)</p> 	<p>WASTE STORAGE AREA</p> 
<p>SAMPLES OR SPECIMENS LOADING POINTS (NAA, RADIOISOTOPES PRODUCTION, ETC.)</p> 	<p>SAMPLES OR SPECIMENS LOADING POINTS (ON THE BRIDGE OVER THE POND)</p> <p>AUXILIARY BRIDGE</p> 	<p>SOME SIGNS AND FIRE EXTINGUISHES</p> 



Fig. 3 Nuclear security practices of 2 MW TRR-1/M-1, TRIGA MARK III

4.2 Self-sustained maintenance over the long term [21, 22]

From INFCIRC/225/Revision 5, sustaining the physical protection regime can be accomplished from security culture, quality assurance (QA), and confidentiality. The QA policy and programmes for physical protection should ensure that a physical protection system is designed, implemented, operated and maintained in relating to threat assessment or design basis threat and meets the State's regulations. It should specify what information needs to be protected and how it should be protected, as well as limiting access to sensitive information.

The sustainability programme should be established by the State, operators, shippers, and carriers and should include the following functions:

- Operating procedures
- Human resource management and training
- Equipment updating, maintenance, repair and calibration
- Performance testing and operational monitoring
- Configuration management
- Resource allocation and operational cost analysis

TRR-1/M-1, Thai 2 MW research reactor under TINT responsibility at present, was operated more than 50 years ago. In order to maintain the sustainability for a long term, TINT life extension plan for this research reactor was set up and ageing management program (AMP) was carried out from 2011, by the technical support from IAEA Expert Mission at the beginning.

The research reactor maintenance and periodical testing for safety and security were performed routinely by TINT together with OAP inspections, at least 4 times a year, following research reactor operating limit and condition (OLC) and SAR requirements. The ageing management measures were set up by TINT to integrate with its QA program, ISO 9001. The screening of Structures, Systems, and Components (SSCs), both passive and active, was performed continuously, as well as the modifications, which some aged SSCs have been repaired or replaced.

To support this RR sustainability, nuclear material accounting and control (NMAC) via OAP inspection and SG-IAEA inspection annually, helps to deter and detect possible removal or misuse of nuclear material by authorized persons. NMAC is needed to be accomplished together with nuclear security and physical protection as the related potential functions of RR long term sustainability.

4.3 Nuclear materials information management [23]

In 2014-2016, the author have prepared, collected all information, compiled, and created the project, "Application of IT to nuclear materials information sharing and regulatory database".

This project supports nuclear material accounting and control of SG/NPT, which Thailand signed and ratified with IAEA. Unfortunately, it was not accepted from OAP to submit to IAEA in April, 2016, for their technical/financial assistance in 2018, which is expected to have a starting operation.

In Thai fiscal year 2016-2017, as one of the OAP personnel in SG/NS group of BNSR (Bureau of Nuclear Safety Regulation), the author is still working for accomplishment of domestic nuclear material database. The information technology of modern software and templates are applied and some success is obtained as the following.

- Nuclear materials (NM) Survey templates for radiation facilities (Thai & English)
- Demonstration module (CourseLab program), Thai & English, for filling Domestic LOF form
 - Domestic LOF form is not official IAEA form but the author has designed to obtain the information of nuclear materials in location outside facility, following BRSR License forms and IAEA-LOF form, as well as concerning legislative domestic and international instruments.
 - BRSR is Bureau of Radiation Safety Regulation.
 - This form cannot apply for TRR-1/M-1 (Thai 2 MW research reactor), which PIL/MBR filling is required. Its nuclear materials are nuclear fuels and some concerning.
- Domestic NM database via Microsoft Access 2010 (Thai)
 - The domestic nuclear materials information (i.e., licensing, facility locations, quality/quantity, irradiation status, and etc.) were selected and extracted from radioactive materials/sources/equipment database of BRSR.
 - All information were identified, added more details/reports, etc. They are created and compiled in several Tables in the same file of Microsoft Access 2010.
 - Have a prepared database for the next fiscal years based on the starting fiscal year 2016 (2559 B.E.).
 - Have the options for the attachments of OAP inspection reports and some domestic/international legislative/technical information concerning LOF.
 - Can demonstrate and print out via Access 2010 in tables, reports, forms, and EXCEL 2010 spreadsheet.

5. Conclusion

To maintain long term sustainability of safeguards and security of nuclear materials, the state regulations and national policies are required to implement relating to NPT, CPPNM, UNSCR 1540, and IAEA nuclear security regime recommendations. The current concerning domestic NM regulatory laws, enforced in 2016, were Nuclear Energy Act, B.E. 2559 (2016) and The Proclamation of Office of Atomic Energy for Peace B.E. 2559 (2016), "Security procedure for nuclear material and nuclear facilities".

The roles of IAEA as the SG responsible organization according to NPT are described, as well as the implementation of SG/NS of the State following IAEA requirements and provisions. The nuclear security practice of TRR-1/M-1 under the responsibility of TINT is also presented.

The progress of the author's project to create NM database for national NMAC supporting, was succeeded some parts via CourseLab and Microsoft Access-2010 programs. This project is expected to serve the increasing of NM utilization in locations outside facilities in the future.

6. Acknowledgement

The author would like to appreciate for all sources of technical information, mostly obtained via internet search. Thanks for the cooperation from Reactor Operation group and Safety Unit of

Thailand Institute of Technology (Public Organization) or TINT, as well as some concerned personnel of Office of Atoms for Peace or OAP, for available technical information of TRR-1/M-1 and domestic nuclear materials.

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