Safeguards by Design (SBD) and Current Status of SBD for Advanced Small Modular Reactors (SMRs)

Jae-Sung Lee, Safeguards Analyst
SGCP-CCA, Department of Safeguards, IAEA

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Safeguards by Design (SBD)

- Integration of **safeguards considerations into the design process** (new or modified facility) from initial planning through design, construction, operation, modification and decommissioning

- **Voluntary process** which does not replace a State’s existing obligations for provision of information to the IAEA **under its safeguards agreement**
Lessons learned from SBD experience

• Non-Nuclear Weapon State (NNWS) imported dry canisters from Nuclear Weapon State (NWS)

• Difficult-to-access area → Dual Containment/Surveillance (C/S) measures
Tamper-indicating protection on lifting yokes

Fixing points by using extension plate for grounding

Sealing enclosure with tamper-indicating cable conduit

Magnetic clips attach conduit to cask
Benefits of SBD Application

- **Reduces need for retrofit** for the installation of safeguards instrumentation
- Facilitates **effective and cost-efficient safeguards** implementation
- **Reduces operator burden** by optimizing inspector time in the facility
- **Increases flexibility** for future safeguards equipment installation
- **Facilitates joint-use** of equipment (Operator/IAEA)
SBD Stakeholders

- Designers/Vendors
- Operators/Owners
- Regional/State Authority
- Equipment Suppliers
- Technology R&D Community
- IAEA
Member State Support Programme (MSSP) tasks for advanced SMRs

• Canada, China, Finland, France, Republic of Korea, Russian Federation, United States (extendable to other States)

• Technologies include barge-based floating power units (FPU), integral pressurized water reactors (PWRs), molten-salt reactors (MSRs), high temperature gas-cooled pebble-bed reactors (HTGR), sodium-cooled fast reactor, microreactors (district heating)

• Goal is to work with IAEA Member States to:
  - raise awareness of safeguards with technology designers
  - evaluate design aspects that could impact safeguards
  - investigate potential safeguards implementation strategies, or even design modifications
MSSP task for advanced SMRs

• Task Objective of identifying the key technical challenges for safeguards implementation and steps to be taken on SMRs
• MSSP task, SBD for SMRs, initiated in 2018
• Develop / demonstrate / implement innovative and effective concepts and approaches to meet safeguards requirements for the new types of SMRs
• Design information handled as highly confidential
Key outputs of MSSP tasks for SMRs

• Developing a model Design Information Questionnaire (DIQ)
• Developing nuclear material accountancy and control strategies
• Evaluating and testing the technical feasibility of safeguards measures
• Safeguards approaches for the target SMRs
• Safeguards technical report (STR)
Floating Power Units (FPUs)

- SP-1 ID: 18/CCA-002
- Task title: Safeguards by Design for Small Modular Reactors
- Task proposal sent on 17 July 2018
- Acceptance letter received on 31 October 2018
- Kick-off meeting on 04 February 2019
- Initial DIQ received on 20 September 2019 (KLT-40S)
- Revised DIQ received on 30 April 2021 (KLT-40S)
- Initial DIQ received on 24 March 2023 (RITM-200M)
- Technical meeting on 30 May – 2 June 2023
Akademik Lomonosov

Image source: Google Maps
Application of Safeguards

The Agreement should provide for the Agency’s right and obligation to ensure that safeguards will be applied, in accordance with the terms of the Agreement, on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices. (paragraph 2, INFCIRC/153 Corrected)
Territorial and International waters

- **Territorial waters:** State controls up to 12 nautical miles (NM), or 22 km, from shore (incl. airspace)

- **Contiguous zone:** Up to 24 NM (44 km) from shore a State can prevent and punish infringement of its customs, fiscal, immigration and sanitary laws occurring within its territory or territorial waters

- **Exclusive Economic Zone (EEZ):** State has control of all economic resources up to 200 NM (370 km) from shore

- **International Waters:** >12 NM (22 km) from shore

Barge-based Floating Power Units

- Akademik Lomonosov floating nuclear heat and power plant for providing electricity and heat energy for onshore consumers in Pevek
- Two KLT-40s reactors (35 MWe per unit) cooled by pressurized light water
- Upon the request of Russian Support Programme, other types of floating nuclear power plants have been included in the scope of Floating Power Units (FPU) within the task from the year 2022
- Initial DIQ received on 24 March 2023 (RITM-200M)
- **RITM-200M is export model; Sub-task of Akademik Lomonosov has been closed within the framework of the task** (agreed in June 2023)
Safeguards Challenges for FPUs

- Design features of fuel handling machines and fuel storages
- Factory-sealed core not having fuel storages and fuel handling machine
- Longer refueling cycles
- Legal challenges because of mobile nature
- Legal considerations between Supply State, Host State and the IAEA
- Misuse of the facility during transit
- Design Information Verification (DIV) during the construction of the plant
Safeguards Challenges for FPUs

- New safeguards approach customized for floating power units
- Conducting DIV for verifying the DIQ during refueling of the power units in Supply State
- Conducting inspections for nuclear material during refueling process in Supply State
- Safeguards application in territorial waters and non-territorial waters
- Access to the FPUs in different States for the same nuclear facility
- Roles of national safeguards authorities, designers, vendors, operators
- Training of safeguards for the safeguards inspections and visits
Molten Salt Reactors (MSRs)

- Bulk handling SMRs with fuel in liquid state
- DIV necessary prior to key components becoming inaccessible
- DIV during construction
  - Vessels to be calibrated
  - Authorization of various joint-use equipment
  - Vessel connection and loading/unloading system
- Destructive assay samples to be taken
- Integration of safeguards in the early stage of design process to avoid retrofits
Molten Salt Reactors (MSRs) (cont.)

- Moltex Stable Salt Reactor Wasteburner 300 (SSR-W300 of Moltex) and Integral Molten Salt Reactor (IMSR of TEI) proposed for the MSSP task

- Receipt of the DIQ of SSR-W300 and Waste to Stable Salt (WATSS) facility in 2021. SSR-W300 designed to use spent fuel from nuclear reactors; WATSS is a pyroprocessing plant for the SSR-W300

- Design information of IMSR to the Agency in March 2021
Integral PWRs

- Limited access for safeguards verification
- Longer refuelling cycle
- Several modules in a plant
- DIVs
- Containment/Surveillance (C/S) measures on the integral types of SMRs
Integral PWRs

- **System-integrated Modular Advanced Reactor 100 (SMART100)**

  - The SMART100 with two modular units and an integral PWR with electrical power of 110 MWe per unit. Standard design licensing process in the ROK under way
  - Draft Safeguards Technical Report (STR) ready to be finalized in 2023
Integral PWRs

- **NUWARD**
  - Task proposal delivered on 29 July 2020
  - Acceptance letter received on 25 November 2020
  - Pre-kick-off meeting with POC on 15 February 2021
  - Preliminary DIQ received on 20 October 2021
  - Kick-off meeting on 22 February 2023

- **LUTHER and LDR**
  - Two micro SMRs (VTT’s heating reactor and LUT Heating Experiment Reactor) proposed by Finland.
  - Preliminary design information delivered to the Agency on 30 April 2021.
  - In-person review meeting held on 7 November 2022
HTGR

- Safeguards considerations on the nature of fuel, a large number of pebble items, non-identifiable items
- Verification of fresh fuel being loaded into the core
- Verification of the spent fuel being discharged from the core
- Silo loading verification
- Silo sealing
- Accountancy of operational parameters and damaged fuel verification
HTGR

• HTR-PM
  - The construction of current HTR-PM plant completed and the unit 1&2 reactors in operation
  - The Chinese HTR-PM which was not designed for the application of safeguards
  - Technical meeting on 6 – 7 June 2023

• Xe-100
  - Canada informed that Xe-100 would be newly added to the task in 2022
  - Technical meeting with X-energy held in virtual mode on 14-17 November 2022
  - Progress review meeting on 14 – 16 June 2023
Conclusion

• IAEA working on incorporating safeguards with safety and security of advanced SMRs for Member States

• SBD to facilitate the development of safeguards approaches on the advanced SMRs proposed by Member States

• Early voluntary interaction with stakeholders to avoid retrofits and to increase flexibility for safeguards implementation
Thank You
For Your Attention