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Basic Principles of Safeguards by Design

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Abstract: This paper presents basic principles of Safeguards by Design (SBD), whereby the International Atomic Energy Agency (IAEA) provides guidance to State and regional safeguards authorities, designers, equipment providers and prospective purchasers on the importance of taking international safeguards into account when designing or modifying a nuclear facility or process.

Keywords: nuclear safeguards, facility design, safeguards by design

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Princípios Básicos de Salvaguardas desde o Design

Resumo: Este artigo apresenta princípios básicos de Salvaguardas desde o Projeto (SBD), para os quais a Agência Internacional de Energia Atômica (AIEA) fornece orientação às autoridades de salvaguardas estaduais e regionais, projetistas, fornecedores de equipamentos e potenciais compradores sobre a importância de levar em conta as salvaguardas internacionais ao projetar ou modificar uma instalação ou processo nuclear.

Palavras-chave: salvaguardas nucleares, projeto de instalações, salvaguardas desde o projeto

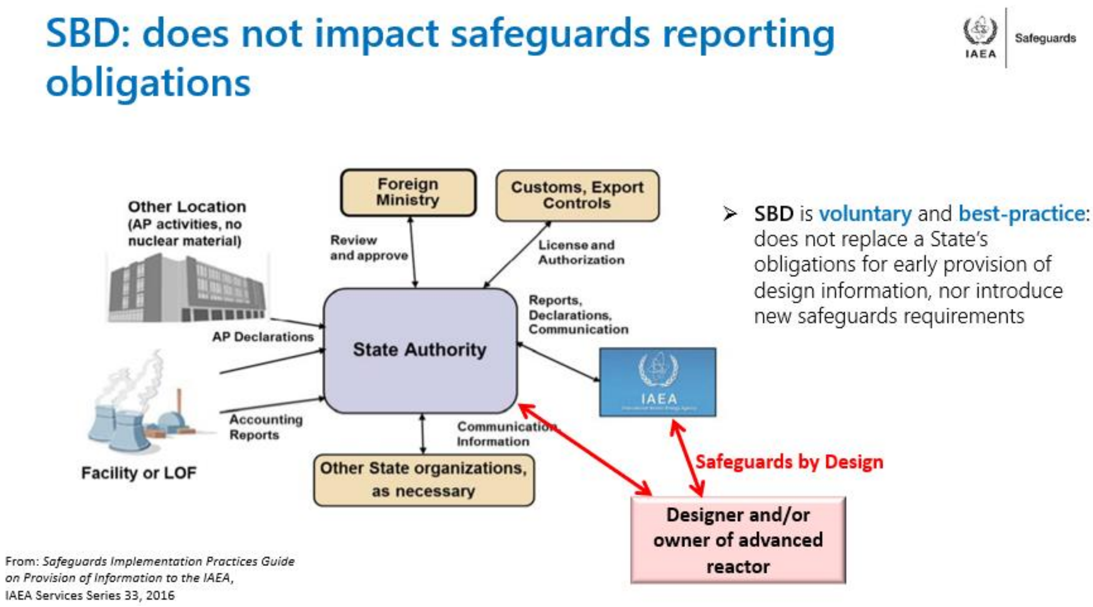
1. INTRODUCTION

This paper presents basic principles of Safeguards by Design (SBD), whereby the International Atomic Energy Agency (IAEA) provides guidance to State and regional safeguards authorities (SRAs), designers, equipment providers and prospective purchasers on the importance of taking international safeguards into account when designing or modifying a nuclear facility or process.

A voluntary best practice, SBD allows for informed design choices to optimize international safeguards requirements alongside economic, operational, safety and security factors, and reduces the resulting burden to all stakeholders. It is applicable to all aspects of the nuclear fuel cycle, and to any phase from initial planning and design through construction, operation, waste management and decommissioning. For new nuclear facilities, especially novel designs or processes, the earlier the discussion of safeguards is taken into account, the better: SBD allows for safeguards to be built 'into' the system, rather than around it afterwards. SBD also applies at any level of technology integration, from components/processes/sub-systems to full facilities, and at the level of the State fuel-cycle planning, regulation, and safeguards management.

It is important to note that SBD is a voluntary process which does not increase or replace a State's existing obligations, but can lead to additional benefits for all stakeholders in terms of effectiveness and efficiency of international safeguards implementation, including the reduction of burden on operators.

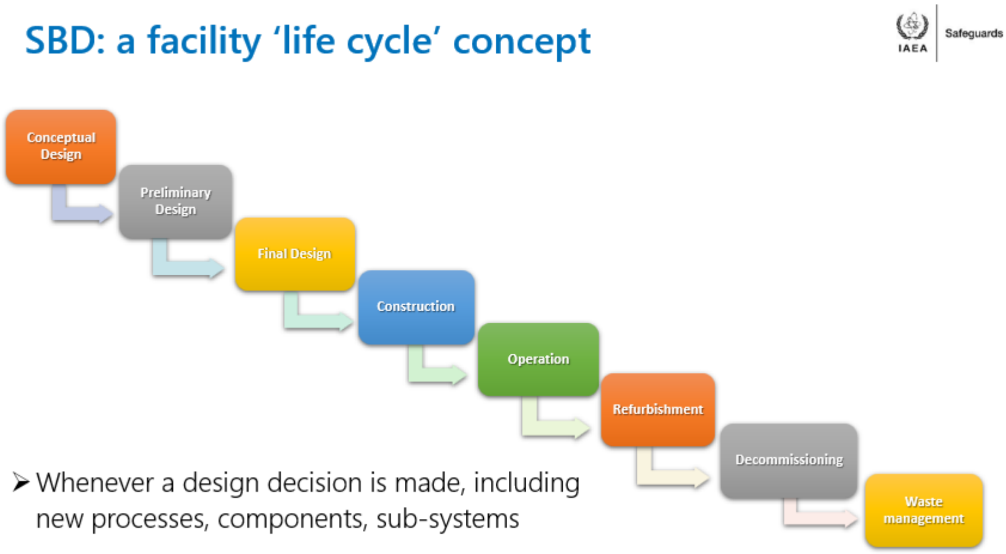
Figure 1: SBD: does not impact safeguards reporting obligations



2. BACKGROUND

SBD is a demonstrated collaborative risk-management approach whereby international safeguards considerations are integrated into the development of a new or modified nuclear facility or process, at any phase from initial planning through design, construction, operation and decommissioning. SBD is a voluntary best practice that neither replaces a State's obligations under its safeguards agreement for early provision of design information to the IAEA, nor introduces new requirements: SBD simply shifts the discussion earlier in the design process, in order to facilitate more efficient and effective safeguards implementation, at any point in the nuclear fuel cycle [1]-[8].

Figure 2: SBD: a facility 'life cycle' concept



As a best practice in the nuclear industry, SBD is not new. For decades the industry's role in facilitating efficient safeguards implementation has been recognized, particularly in cases involving complex facility layouts or novel nuclear-material forms and flows. A significant example of this is the Rokkasho Reprocessing Facility in Japan, which, as the first commercial-scale reprocessing facility in a State having a Comprehensive Safeguards Agreement with the IAEA, was the subject of extensive collaborative safeguards development in parallel with its design and construction, starting in the late 1980s. The IAEA, working closely with the facility operator, State authority, and Japanese research and development (R&D) support, developed a customized approach including unattended monitoring and sampling systems, and both independent and joint-use equipment [9].

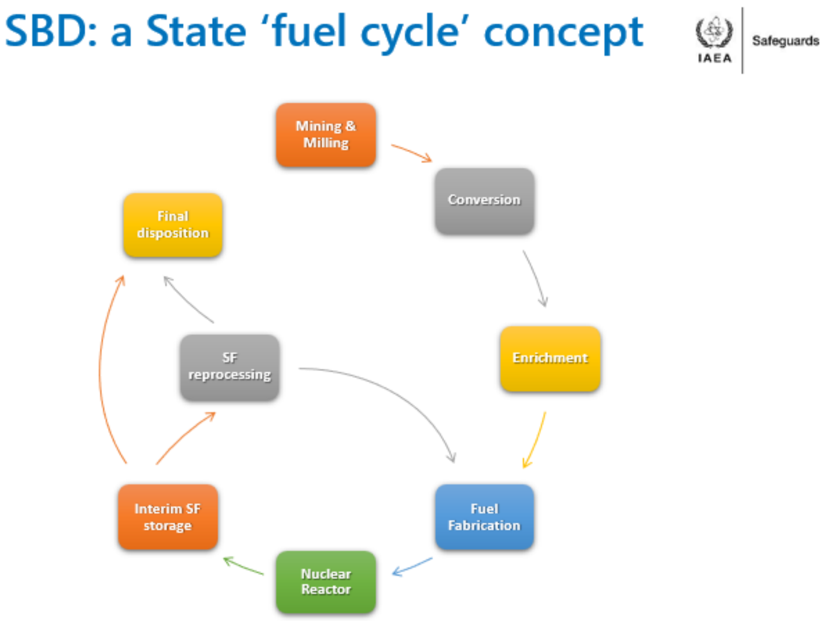
Another significant early example is the unattended monitoring system (UMS) and other customized technical measures developed for pressurized heavy water reactor (PHWR) facilities starting in the late 1970s with Canadian R&D support. In this case, the on-load-refuelling of the CANDU design necessitated the incorporation of customized core-discharge monitors and bundle counters in the standard facility design, providing continuity of knowledge of the fuel flow despite its inaccessibility for physical inspection prior to the spent fuel bay [10][11].

3. GENERAL PRINCIPLES

These two early examples of SBD underscore several important aspects of SBD that remain generally relevant in today's evolving nuclear industry:

- Applicable to all nuclear-fuel-cycle facilities and processes (not just reactors);
- Particularly important for facilities with complex nuclear-material forms and flows;
- Applicable to sub-systems, processes, and components of all sizes;
- Early discussions among all relevant stakeholders are mutually beneficial; and
- Can involve customized equipment requiring the State's time and resources to develop.

Figure 3: SBD: a State 'fuel cycle' concept



In addition, these two early examples demonstrate the main benefits of SBD, which remain valid today and apply to all stakeholders:

- Reduces the need for retrofitting safeguards equipment after facility construction or modification;

- Facilitates the use of advanced safeguards technologies, such as UMS and remote data transmission (RDT);
- Can involve significant State resources, but avoids future burdens;
- Allows the integration of cost-effective measures that would otherwise not be feasible, directly into the facility design;
- Facilitates the shared-use of equipment by the State and the IAEA;
- Facilitates the sharing of the operator's process monitoring and other operational data;
- Provides flexibility for upgrading safeguards measures as needed; and
- Facilitates harmonization of design requirements across similar technology types.

The overall benefit of SBD is better understanding by all stakeholders of respective safeguards obligations and technical needs, and a resulting reduced risk to project scope, schedule, budget and licensing.

As a concept of engagement, SBD has broad and adaptable applicability. In its simplest manifestation it facilitates the installation of IAEA safeguards equipment (e.g., cameras, seals, detectors, supporting equipment), often involving design accommodations (e.g., wall brackets, penetrations, conduits, instrument cabinets, and sealing points). Typically, these represent minor modifications with minor cost implications when addressed in the early design phases, but significant retrofit costs once a design is finalized, or built. In the course of routine operations or maintenance, SBD reduces the probability of accidental interference with safeguards measures that would initiate follow-up activities by the IAEA (e.g., inadvertent obstruction of cameras, damage to seals, shielding of detectors). In other words, SBD contributes to good engineering design and planning.

In its more complex applications, early SBD facilitates design modifications that can:

- Accommodate more efficient and effective safeguards measures; e.g., facilitating customized UMS, with or without RDT of safeguards data to IAEA headquarters or field offices; or
- Increase the inherent safeguardability of a facility, component, or process; e.g., modifications to the form or flow of nuclear material, container design, or facility layout that make diversion or misuse of the nuclear material more technically difficult, or make safeguards measures (e.g., seals) easier to apply.

4. GENERIC EXAMPLES OF SBD

Applications of SBD can be envisioned for a wide range of nuclear facilities, ranging from innovative new designs, to the decommissioning of existing installations.

SBD example 1: A designer of a molten-salt small modular reactor (SMR), as recommended in the 'pre-licensing review' process of the State nuclear regulator, engages in early SBD discussions with the State and/or regional safeguards authority (SRA) and the IAEA. Safeguards measures are negotiated, involving UMS, RDT, and the secure sharing of operational data. The designer works with the IAEA, SRA, and operator to incorporate these requirements, including development of customized equipment and analysis methods. A prototype of the molten salt SMR is built, and an optimized, effective safeguards approach is implemented.

SBD example 2: A nuclear power plant operator initiates procurement of a spent fuel dry storage facility, and includes a requirement for consideration of safeguards in the bid specification. A potential supplier discusses the safeguards needs for spent fuel dry storage initially with the operator, and later also with the SRA and IAEA. The supplier's successful bid includes features that allow the efficient application, verification, and replacement of

IAEA seals, including a seal that verifies immobilization – i.e., 'continuity of knowledge' that the container has not been breached, or moved. The spent fuel dry storage facility is built, and an optimized, effective safeguards approach is implemented.

SBD example 3: A fuel fabrication facility plans to decommission an old processing building on its site, and – as part of the process to receive a decommissioning licence from the regulator – engages in SBD discussions with the SRA and IAEA. The operator learns that the average concentration of uranium in the decommissioning waste, per safety requirements, would still be high enough to require continued IAEA safeguards – contrary to the objective of the decommissioning plan. The operator works with the IAEA and SRA to design a modified process leading to lower average concentrations of uranium, and allowing the IAEA to independently verify these concentrations in an efficient manner. The legacy building is decommissioned, and an optimized, effective safeguards approach is implemented, which includes termination of safeguards on the waste material.

5. CONCLUSIONS

Since the mid-2000s, the IAEA has increased its efforts to support the needs of Member States in the design and deployment of new nuclear facilities, including through the consideration of safeguards alongside safety and security factors early in the design process. With the goals of reducing operator burden and avoiding retrofitting, as well as improving safeguards efficiency and effectiveness, SBD has become a highly beneficial best practice for both States and the IAEA. SBD interactions contribute to better understanding and awareness of safeguards needs by Member States and the nuclear industry, and enhance future IAEA-Member State cooperation in safeguards implementation regarding nuclear facilities.

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CONFLICT OF INTEREST

Jeremy Whitlock declares no conflicts of interest.

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