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Title: Third International Meeting on Next Generation Safeguards (NGS3): Synopsis of the Safeguards-By-Design Reactor Working Group Conclusions ~~(Slides)~~

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THIRD INTERNATIONAL MEETING ON NEXT GENERATION SAFEGUARDS (NGS3): SYNOPSIS OF THE SAFEGUARDS-BY-DESIGN REACTOR WORKING GROUP CONCLUSIONS

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ABSTRACT

The Third International Meeting on Next Generation Safeguards (NGS3) was held in Washington, DC on 14–15 December 2010 and focused on the Safeguards-by-Design (SBD) concept. The IAEA has described the SBD concept as an approach in which "international safeguards are fully integrated into the design process of a new nuclear facility from the initial planning through design, construction, operation, and decommissioning." The United States Department of Energy has initiated a project by way of its Next Generation Safeguards Initiative (NGSI) to establish a global norm for the use of SBD. The NGSI SBD program is being developed in parallel with a similar effort at the IAEA, while taking into account the IAEA's SBD achievements and future plans. The NGSI program is pursuing the establishment of a SBD global norm through DOE laboratory studies, international workshops, engagement with industry and the IAEA, and setting an example by way of its use in new nuclear facilities in the United States. This paper will report on the discussion topics and present details of the final recommendations of the NGS3 Reactor Working Group. This working group had representation from industry, government, and former IAEA inspectors from around the world. The working group discussed how to make reactor design more amenable to both domestic and international safeguards requirements. Among the key issues considered, the group concluded that the IAEA and nuclear industry should consider an improved means for identifying and tracking nuclear fuel from manufacture to disposal; that new facility designs need to take into consideration the space, utility, and other requirements for installing IAEA seals, surveillance systems, servers, and conduit for on-site storage of and possible remote transmission of safeguards data; the need exists to verify and track mixed oxide fresh fuel and CANDU spent fuel in unattended mode and the IAEA should define these specific requirements and make them available to the broader international safeguards community and nuclear industry through publications and especially through joint forums that share the latest developments in safeguards technology and approaches with nuclear facility operators and facility designers.

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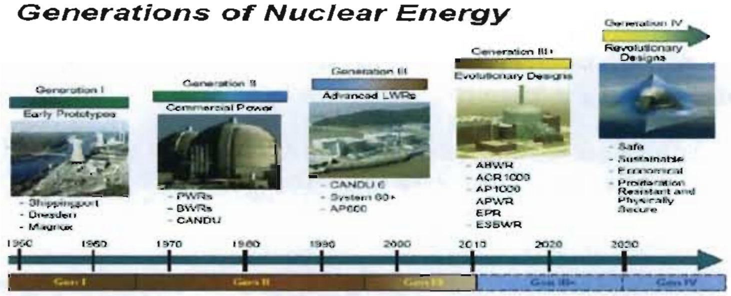
Outline

- Introduction
- Next Generation Reactors
- SBD Features and Attributes
- IAEA Safeguards Objectives
- SBD for Next Gen Reactors - Consensus at NGS3
- Recommendations

Introduction

Safeguards by Design (SBD): An incorporation of safeguards requirements early in the design phase of a new nuclear facility to minimize plant life-cycle costs by averting potential plant retrofits after construction and operation of the plant.

Generations of Nuclear Energy



SBD- Six Key Reactor Attributes

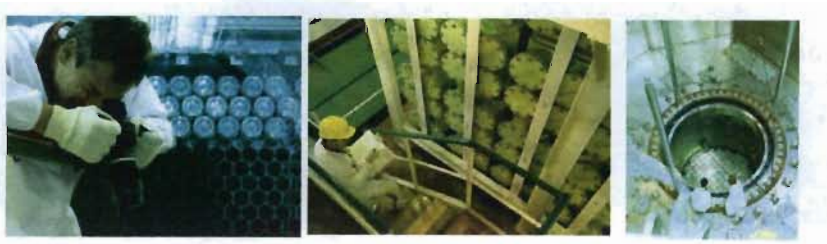
- Cost effectiveness
- Safety
- Security and nonproliferation
- Grid appropriateness
- Commercialization roadmap
- The fuel cycle—front end and back end

Characteristics of GEN III/IV Reactors

- **GEN III/III+ Reactors (LWRs, HWRs, HTGRs, FBRs)**
  - Economical: less fuel cost (~5-7%) uranium/MWh, >35% thermal efficiency (for example, LWRs)
  - Safer: 100-1000 below NRC's core melt and large release frequencies
  - Extended reactor life: from 40 to 60 years
- **GEN IV Reactors (Thermal and Fast Reactors)**
  - At various theoretical design stages (deployable by 2030)
  - Further improvement in performance, nuclear safety, proliferation resistance
  - Reduction in waste generation, natural resource utilization
  - Cost savings in building and operating

Safeguards-By-Design Benefits

- **Enhance nuclear safeguards**
- **Reduce cost to the IAEA / increase SG effectiveness**
- **Minimize construction project risk**



Safeguards-By-Design NGS3 Key Topics

- The IAEA has a leadership role in promoting SBD
- Gen III and III+ reactor designs relatively mature
- IAEA safeguards in Nuclear Weapons States (NWS)

IAEA Safeguards Objectives

Material Category	Fuel Types	Amount of SQ	Timeliness Goal
Unirradiated Direct-Use	MOX Fresh Fuel	Pu = 8 kg	1 Month
	Fresh Fuel	U-233 = 8 kg	
Irradiated Direct-Use	Core Fuel, Spent Fuel	Pu = 8 kg	3 Months
	Core Fuel, Spent Fuel	U-233 = 8 kg	
Unirradiated Indirect-Use	LEU Fresh Fuel	U-235 = 75 kg	1 Year
	Th Fresh Fuel	Th = 20 T	
Unrecorded Production		Pu = 8 kg	1 Year
		U-233 = 8 kg	

Diversion & Concealment Activities

Diversion	Method	Timing
LEU FF Diversion	Substitution of dummy element for actual element	After FF receipt verification - prior to Core Loading
MOX FF Diversion	Substitution of dummy element for actual element	Prior to Core Loading
SF Assembly Diversion	Substitution of dummy element for actual element	From Reactor Core, SF Pool, or SF transfer cask
SF Pin Diversion	Substitution of dummy pin for actual pin	From SF Pool or SF transfer cask
Unreported Pu Production	Insertion of fertile item in reactor for irradiation -In CF – (PWR Guide Tubes or BPR)	From SF Pool or SF transfer cask

Impact on Current Safeguards Regimes

- **Fresh and spent MOX fuels- EACH FA contains >1 SQ Pu**
  - Requiring additional safeguards procedures
- **Gen III/III+ LEU SF = higher burn-ups than Gen II LEU SF**
  - Gen III/III+ LEU SF Contains more Pu than LEU SF from GEN II LWRs
  - Rule of thumb – 2 PWR SF ~ 1 SQ and 4 BWR SF ~ 1 SQ
- **Increase time between refueling & SF cooling time in pool**
  - Impacts physical inventory verification schedule and or SG approach
- **Fabrication of MOX fuel requires more Pu production**
  - Impacts safeguards process on spent fuel reprocessing
    - More SF transports
    - More reprocessing facilities and/or Pu throughput
    - More separated Pu and/or stored Pu

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NGS3 Reactor WG Recommends:
For Safeguards Universally:

- **Need SGs requirements early in the design stage**
- **Space, utility, and other requirements for SG systems**
- **The IAEA keeps requirements updated and distributed**
- **Create annual international joint forum**
  - Sharing the latest developments in safeguards technology
  - All safeguards partners – IAEA, Regional, State, Commercial
  - Similar to WANO for operations and safety
- **Business case for SBD to commercial nuclear industry**

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NGS3 Reactor WG Consensus:
For Reactors (Part 1)

- **Share plant operator's instruments for the SGs data**
- **Improve ID/tracking of fuel assemblies - cradle to grave**
- **Design spent fuel handling for ease of safeguards**
- **Efficient transfer SGs - SF ponds to interim SF storage**
- **SF pond dedicated area for verification of fuel assemblies**

NGS3 Reactor WG Concensus :
For Reactors (Part 2)

- IAEA publishes SG requirements for ISFSIs widely
- Unattended verification of the receipt of MOX
- Improved IAEA C/S CoK of fresh MOX reactor storage
- IAEA defines an "item" in special cases involving verified spent nuclear fuel – CANDU bundle basket vs. assembly
- Use most accurate current burnup codes
  - Calculating and declaring the nuclear material in SF

Recommendations

- Safeguards guidance for GEN III/III+ light water reactors was developed based on
  - IAEA safeguards objectives and requirements
  - Lessons learned from IAEA safeguards experts
  - Interaction of industry, lab, regulatory, and IAEA personnel
  - Specific design features to the GEN III/III+ LWRs (e.g., high burn-ups, MOX fuel, cooling time)
- Many of the best practices identified, although specific for GEN III/III+ LWRs, are applicable for other GEN III/III+ and GEN IV reactors
- Experience at EPR and ACR evidenced the importance of early incorporation of SBD in enhancing safeguards effectiveness and saving cost