Supplement of

International safeguards for the final disposal of spent nuclear fuel – why, what and how

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INTERNATIONAL SAFEGUARDS FOR THE FINAL DISPOSAL OF SPENT NUCLEAR FUEL – WHY, WHAT AND HOW

11.11.2021 | I. NIEMEYER, K. AYMANNS, G. DEISSLMANN, D. BOSBACH
Institute of Energy and Climate Research, IEK-6: Nuclear Waste Management

SESSION 4A EN
Activities in international research programs and collaborations
NUCLEAR SAFEGUARDS

To deter the spread of nuclear weapons by the early detection of the misuse of nuclear material or technology

After the first nuclear bomb was dropped on Hiroshima on 6 August 1945, US-President Harry Truman unveiled the top-secret Manhattan Project.

Atoms for Peace Speech
US-President Dwight D. Eisenhower, UN General Assembly, 8 December 1953

Treaty on the Non-Proliferation of Nuclear Weapons (NPT), 1970

- Non-proliferation (Art. I & II), Safeguards (Art. III)
- Peaceful use of nuclear energy (Art. IV & V)
- Disarmament (Art. VI)

Generic safeguards objectives

- To detect any diversion of declared nuclear material at declared facilities or locations outside facilities where nuclear material is customarily used (LOFs)
- To detect any undeclared production or processing of nuclear material at declared facilities or LOFs
- To detect any undeclared nuclear material or activities in the state as a whole
NUCLEAR SAFEGUARDS

To deter the spread of nuclear weapons by the early detection of the misuse of nuclear material or technology.

IAEA Safeguards in 2020

Verifying the peaceful use of nuclear material

184 States with safeguards agreements in force, of which
136 States had additional protocols in force
31 States with comprehensive safeguards agreements and original small quantities protocols
63 States with comprehensive safeguards agreements and amended small quantities protocols
221,432 significant quantities of nuclear material
1,321 nuclear facilities and locations outside facilities
145 million regular budget
+27 million extra budgetary
875 staff from 95 countries

Conducted
2,856 in-field verifications
12,767 days in the field

Verified
23,600 seals applied to nuclear material, facility critical equipment or IAEA’s safeguards equipment at nuclear facilities
2,362 days under quarantine in country

Collected
460 environmental samples
489 nuclear material samples

Acquired
1,264 commercial satellite images

Remotely monitored
142 facilities

Utilized
1,038 non-destructive assay systems for the measurement of nuclear material

Maintained
1,530 surveillance cameras at nuclear facilities

We concluded that for...

72 States all nuclear material remained in peaceful activities
103 States declared nuclear material remained in peaceful activities
3 States nuclear material, facilities or other items to which safeguards had been applied remained in peaceful activities
5 States nuclear material in selected facilities to which safeguards had been applied remained in peaceful activities
INTERNATIONAL COLLABORATION IN SAFEGUARDS

Member State Support Programmes in IAEA Safeguards

21 Member States’ Support Programmes

[Diagram showing flags of member states: Germany, France, Finland, Hungary, Japan, Netherlands, Czech Rep., China, Canada, Brazil, Belgium, Australia, Argentina, USA, Russia, South Africa, Spain, Sweden, UK, Korea]
INTERNATIONAL COLLABORATION IN SAFEGUARDS

Safeguarding final disposal of spent nuclear fuel - Overview

1988: IAEA Advisory Group on Safeguards related to Final Disposal

1991: IAEA Consultants’ Meeting on Safeguards for Final Disposal

1994-1998 IAEA SAGOR Working Group

1999-2006 IAEA Group of Experts (SAGOR II)

2006-2017: IAEA ASTOR Working Group

2018-2019: Consolidation of ASTOR and SAGOR tasks

2020: ESARDA Working Group on Final Disposal

SAGOR: Safeguards for Geological Repositories
ASTOR: Application of Safeguards to Geological Repositories
ESARDA: European Safeguards Research and Development Association

Safeguards for Geological Repositories: Reports and activities


**ASTOR (2006-2017)**

**Application of Safeguards to Geological Repositories: Reports and activities**

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**Technology principle and brief description**

- Technology readiness level
- Technology limitations
- Estimated costs
- Sustainability, standardization, supply chain
- Ease of use / operator skill / infrastructure needs
- Data validation / authentication
- Expected ‘Alarm’ rates

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**Technologies**

- Design Information Verification (DIV)
- Non-destructive analysis (NDA) verification
- Containment and surveillance (C/S) measures and canister ID
- Satellite imagery
- Geophysical techniques (i.a. seismic detection, directional radar technology)
- Long-term management of safeguards-related data

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**STR-384 (2017): Technologies Potentially Useful for Safeguarding Geological Repositories**

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**SARTR II**

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**Design Information Verification (DIV)**

- Non-destructive analysis (NDA) verification
- Containment and surveillance (C/S) measures and canister ID
- Satellite imagery
- Geophysical techniques (i.a. seismic detection, directional radar technology)
- Long-term management of safeguards-related data
DESIGN INFORMATION VERIFICATION (DIV)

Detection of undeclared constructions

Simultaneous location and mapping (SLAM) (GER-DLR)

S. Kaiser, E. Munoz Diaz, P. Robertson (2016): Study on the Feasibility of FootSLAM for Use During Safeguards Verification Activities. JOPAG/03.16-PRG-423

SATELLITE IMAGERY (SI)

Change detection, deformation analysis

TerraSAR-X images acquired at May 23 (right) and June 3 (left)
Top: Interferogramm
Left: Color-coded backscatter intensity

Application of SAR interferometry and non-coherent change detection techniques (CAN/FIN/GER-Jülich/JPN)


Slide 9
GEOPHYSICAL TECHNIQUES
Detection of undeclared / unauthorised activities


CONSOLIDATION OF SAGOR AND ASTOR RECOMMENDATIONS (2018-2019)

To support the Agency’s knowledge management for future generations of safeguards staff in future geological repository programs

QUESTIONS AND ANSWERS REGARDING GEOLOGICAL REPOSITORY SYSTEM SAFEGUARDS IMPLEMENTATION

REFERENCES DOCUMENTS

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   2. INF/CRC/240 (Corrected), Model Protocol Additional to the Agreements Between States and the International Atomic Energy Agency for the Application of Safeguards, International Atomic Energy Agency, September 2005 ........................................... 8
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   15. SG-PR-2304, MODEL INTEGRATED REPOSITORY, 2011-02-20 ........................................... 13

44 Q&A's

93 references (incl. abstracts)
CONSOLIDATION OF SAGOR AND ASTOR RECOMMENDATIONS (2018-2019): ACHIEVEMENTS

- Performed diversion path analysis for generic encapsulation plants and geological repositories
- Identified potential safeguards detection points for each facility type and operating phase
- Identified facility-specific technical objectives
- Identified safeguards measures that could be used for each facility
- Developed and assessed a safeguards approach based on IAEA Safeguards Criteria
- Provided input and review of IAEA safeguards policy for spent fuel disposal
- Identified research and development needs and reviewed status of related development tasks
- Supported preparation of a model integrated safeguards approach for each facility type
- Supported preparation and testing of a design information questionnaire for each facility type
- Provided input to a safeguards implementation ‘road map’ developed by the IAEA Department of Safeguards
- Issued a report on the status of technologies that could be used for safeguarding encapsulation plants and geological repositories (STR-384)
FURTHER R&D NEEDS

**Technologies**
- Establish performance requirements for the design of relevant safeguards technologies
- Develop and test appropriate safeguards equipment

**Implementation**
- Determine specific information needs of stakeholders and develop appropriate guidance
- Develop safeguards approaches under the State-level concept
- Develop further approaches on ‘Safeguards-by-Design’ and the ‘Safety-Security-Safeguards’ (3S)

**Data and information management**
- Develop approaches on how information about disposed spent fuel and high-level nuclear waste should be managed, handled, organized, archived, read, interpreted, and secured for the long term (for centuries after repository closure and beyond)
Germany does not have a national safeguards authority of its own and does not carry out safeguards inspections on its own. Sovereign rights in this field were transferred to the EC (DG Energy, EURATOM). EURATOM is the owner of all nuclear fuel in the EU.

The Federal Ministry for Economic Affairs and Energy (BMWi) holds the overall political responsibility as to maintaining any interferences of safeguards activities with domestic regulations.

EURATOM acts as multinational safeguards authority and is the direct contact for the IAEA on the one hand and the operators on the other within the framework of the verification agreement between the IAEA, EURATOM and the EU member states (INFCIRC/193).
KMP: Key Measurement Point
MBA: Material Balance Area
SP: Strategic Point

MBA 2:
- Accounting and re-examination of the plant design data
- No containment/surveillance measures
- No inspection activities
UPDATING THE SAFEGUARDS CONCEPT

Taking into account the 2010 safety requirements (recoverability, retrievability)

- National legislation, safety requirements (recoverability, retrievability)
- Respective geological formation
- Design of the facility, emplacement concept, type of casks
- Evolution of safeguards concepts and approaches

The State-level approach (SLA) for Germany will address the safeguards measures and activities for the geological repository. The given SLA for Germany will be updated in the different lifecycle phases of the repository.
Thank you for your attention.