Overview of INPRO Methodology in the Area of Proliferation Resistance

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I. Introduction

Sustainable INS

- Economics
- Safety (Reactor)
- Safety (Fuel Cycle)
- Infrastructure
- Environment
- Waste Management
- Physical protection
- Proliferation Resistance
Proliferation Resistance (PR): “Characteristic of a nuclear system that impedes diversion or undeclared production of nuclear material, or misuse of technology, by States in order to acquire nuclear weapons or other nuclear explosive devices”.

(Meeting in Como, Italy, IAEA STR-332, December 2002)
I. Introduction

Definition of PR Terms:

- **Degree of Proliferation Resistance**: “Combination of, inter alia, technical design features, operational modalities, institutional arrangements and safeguards measures”

- **Extrinsic PR Measures**: “Results from States’ decisions and undertakings related to nuclear energy systems”

- **Intrinsic PR Features**: “Results from the technical design of nuclear energy systems, including those that facilitate the implementation of extrinsic measures”.

- **Fundamental of PR**: “Extrinsic proliferation resistance measures, such as control and verification measures, will remain essential, whatever the level of effectiveness of intrinsic features”.

(Como II, IAEA STR-332, December 2002)
IAEA Safeguards Objective:

“Timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection”.

(IAEA INFCIRC/153 (corrected))
4 IAEA Safeguards tools and measures:

1. Material accountancy:
   - State system of accounting and control of NM.
   - Accountancy verification.

2. Containment and surveillance (C/S):
   - e.g., seals on containers, TV.

3. Inspection / infield verification:
   - Including Design Information Verification by IAEA inspectors.

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Design Information Verification (DIV):

- Design Information Examination (DIE).
- Comprehensive design verification (during construction).
- Use C/S or existing SG equipment to maintain Continuity of Knowledge.
- Periodic (re) verification of design.
Safeguards effort (frequency of inspections) at a nuclear facility influenced by:

- Material category:
  - Un-irradiated direct use material: Pu, HEU (>20% U235), U233
  - Irradiated direct use material, and
  - Indirect use material: U-nat, U-dep, LEU (<20% U235), Th.

Timely detection goals and significant quantity:
- E.g.: For Plutonium and U233: 1 month / 8 kg
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Safeguards effort at a nuclear facility influenced by:

- Attractiveness of nuclear technology:
  - Enrichment, Reprocessing \( \rightarrow \) direct use material.

- Complexity of nuclear technology:
  - More complex \( \rightarrow \) more potential diversion.

- “Safeguardability” of design:
  - Design features/measures to implement safeguards more effectively and efficiently (Safeguards by design).
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• Basis of INPRO PR Methodology:
  • Korean case studies on DUPIC.

• Focus of INPRO PR Methodology:
  • Potential use of INS for a nuclear weapons program in a given State.

• Scope of INPRO PR assessment:
  • Complete INS in a State or region throughout the full life cycle.
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• **Input** for INPRO Methodology of PR Assessment:
  - Proliferation potentials from **Quantitative PR Analyses**:
    - Analyses to be performed jointly by technology supplier, and experts in Safeguards and in PR.
    - **Determination of Level of PR**, i.e. very weak to very strong, to be defined for several parameters. (method developed within INPRO)
    - **Acquisition Path Analysis** of Nuclear Material used for a nuclear weapons program (method developed in GIF).
  - Analysis whether Safeguards goals are met.
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INPRO methodology for PR Assessment:

• To be performed at 3 levels, i.e. the State level, the INS level, and the facility level.

• Asks Safeguards experts whether Safeguards goals for each of 3 levels can be met effectively and efficiently, i.e.
  • Weak intrinsic PR parameters found in the analysis can be compensated by other intrinsic features or extrinsic measures (higher effort in safeguards).
  • Safeguards implementation costs are affordable for international safeguards authorities and the operators.
  • And, ultimately, asks Safeguards experts whether the INS is an unattractive means to acquire fissile material for a nuclear weapons program.
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II. Structure of the Area of PR

BP

UR1
- CR1.1
- CR1.2

UR2
- CR2.1
- CR2.2
- CR2.3
- CR2.4

UR3
- CR3.1
- CR3.2
- CR3.3
- CR3.4
- CR3.5
- CR3.6

UR4
- CR4.1
- CR4.2

UR5
- CR5.1
- CR5.2
- CR5.3
II. Structure of the Area of PR

Basic Principle: “PR intrinsic features and extrinsic measures shall be implemented throughout the full life cycle for INSs to help ensure that INSs will continue to be an unattractive means to acquire fissile material for a nuclear weapons program. Both intrinsic features and extrinsic measures are essential, and neither shall be considered sufficient by itself”.

Five User Requirements:
2. Low attractiveness of NM and technology.
3. High difficulty and detectability of diversion.
4. Multiple barriers.
5. Optimization of design (costs).

Seventeen Criteria covering all aspects of those UR
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III. Scope of the area of PR

State commitments (legal framework):

- Standards in non proliferation regime:
  - National atomic law: Statutes, Atomic Energy Act
  - Treaties: Non-proliferation Treaty, Bangkok treaty
  - Agreements: Comprehensive Safeguards Agreement, Additional Protocol, etc.
  - Regulatory body & Regulations: State System of Accounting and Control (SSAC)
- National legal frame work to be established meeting international standards.
- Corresponding national institutions to be established.
III. Scope of the area of PR

Attractiveness of Nuclear Material (NM) and Nuclear Technology (NT):

- Characteristics of **NM**: category, quality, classification and quantity.
- Characteristics of **NT**: enrichment, reprocessing and irradiation capacity.

Difficulty and Detectability of Diversion of NM:

- “Safeguardability” and “Safeguards by Design”.

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III. Scope of the area of PR

Multiple Barriers:

• Coverage of all credible acquisition paths.
• Robustness of proliferation resistance barriers and measures.
• Defence in depth.

Optimization of design:

• Inclusion of proliferation resistance in the innovative system design in the design and engineering phase.
• Verification approach measures agreed with national and international authorities.
• Optimize cost of proliferation resistance features and measures.
III. Scope of the area of PR

Necessary inputs for assessment of design related PR issues (e.g., attractiveness of NM):

- Results of analyses to be done by designer together with safeguards experts.

- Analyses include:
  - Quantification of level of proliferation resistance of NES parameters relevant for PR.
  - Diversion/ Acquisition path way analysis.
**III. Scope of the area of PR**

Design Parameters to be determined by designer.

<table>
<thead>
<tr>
<th>Characteristics of NM</th>
<th>Parameter of NM</th>
<th>Level of proliferation resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very weak</td>
</tr>
<tr>
<td>Category of nuclear material</td>
<td>Category of nuclear material</td>
<td>UDU</td>
</tr>
<tr>
<td>Quality of NM</td>
<td>Isotopic composition $^{239}$Pu/Pu (wt%)</td>
<td>Level of proliferation resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak</td>
</tr>
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<td>$&gt;50$</td>
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### III. Scope of the area of PR

<table>
<thead>
<tr>
<th>Initiating Event</th>
<th>Operational State</th>
<th>Diversion Place</th>
<th>Process</th>
<th>Diversion Means</th>
<th>Diversion Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempt</td>
<td></td>
<td>Reactor core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>Reception bay</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Maintenance</td>
<td>Fresh fuel bay</td>
<td>Daily refueling</td>
<td>Storage basket</td>
<td>Abrupt Protracted</td>
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<tr>
<td></td>
<td>Repair</td>
<td>Spent fuel bay</td>
<td></td>
<td>Storage</td>
<td>Ext. container</td>
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<tr>
<td></td>
<td>Testing</td>
<td></td>
<td></td>
<td></td>
<td>Protracted Protracted</td>
</tr>
</tbody>
</table>

**Diversion/acquisition scenario for fresh DUPIC fuel (PRADA)**
III. Scope of the area of PR

**UR1: Legal Framework for Non-proliferation Established**
*(State/INS/Facility level)*

**UR2: Low Attractiveness of Material and Technology**
*(State/INS/Facility level)*

**UR3: Diversion Difficulty and Detectability**
*(Facility level)*

**UR4: Multiple barriers to Proliferation**
*(Robustness)*
*(State/INS/Facility level)*

**UR5: Costs to be Optimized**
*(State/INS/Facility level)*
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IV. Conclusion

• International Safeguards:
  Essential for the proliferation resistance of a nuclear energy system (NES).

• Design features helping to implement international safeguards:
  If implemented at very early design stages improvement of proliferation resistance of NES.
IV. Conclusion

Pre-requisites
- Energy Planning
- Assessment team
- Scope
- NES

Step 1: Familiarization
- INPRO Manual
- Training

Step 2: Inputs
- Designer
- Industry
- IAEA
- INPRO

Step 3: Assessment
- Areas
- Contact with the team
- Contact with the IAEA

Step 4: Report
- NES
- Energy Planning
- Result
- ...

Step 5: Review
- Peer Review
- IAEA Review
...Thank you for your attention
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