IAEA Safeguards: Background, Tools, & Opportunities

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**International Atomic Energy Agency**

- Established in 1957, following President Eisenhower’s “Atoms for Peace”
- U.N. system organization
  - 171 member countries
- Headquarters located in Vienna, Austria
Nobel Peace Prize for 2005 to IAEA and its Director General
International Atomic Energy Agency

Mission:

1) Promote the peaceful uses of nuclear technology

2) Promote a nuclear safety culture

3) Verify that nuclear material is being used exclusively for peaceful purposes
Ensuring that nuclear material is not diverted from peaceful nuclear activities by confirming the correctness and completeness of Member State declarations

"Effective IAEA safeguards remains the cornerstone of the world's nuclear non-proliferation regime aimed at stemming the spread of nuclear weapons and moving towards nuclear disarmament."

- Olli Heinonen, Former Deputy Director General
# Treaty on the Nonproliferation of Nuclear Weapons (NPT)

<table>
<thead>
<tr>
<th>Non-Nuclear Weapons States</th>
<th>Nuclear Weapons States</th>
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<tr>
<td>Commit to nonproliferation</td>
<td>No transfer of technology to NNWS</td>
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<td>Conclude an agreement with the IAEA for the application of Safeguards</td>
<td>Work towards disarmament</td>
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What does the Dept of Safeguards Do?

- Receive States’ declarations
- Perform inspections
  Collect inspection data on materials and facilities
- Compare inspection data to State declarations
- Search for undeclared activities (open source information, satellite imagery, environmental sampling)
Civilian (Power Generation) and Defense
Nuclear Fuel Cycles
Safeguards Inspections - Facilities

- Enrichment Plants
Safeguards Inspections - Facilities

- Power Reactors
- Research Reactors
Safeguards Inspections - Facilities

- Reprocessing Plants
Traditional international safeguards resembled auditing in banking.
Nuclear Materials Accountancy

Material Balance:

\[(\text{Beginning Inventory}) + (\text{In}) - (\text{Out}) = (\text{Ending Inventory})\]

Any apparent difference is termed “Material Unaccounted For” (MUF):

\[\text{MUF} = (\text{Beginning Inventory}) + (\text{In}) - (\text{Out}) - (\text{Ending Inventory})\]

Note: MUF>0 does not necessarily mean that material has been lost!
Nuclear Material Accountancy
How is accounting verified?

- **State Declaration**: State reports nuclear materials inventory and transactions (receipts, shipments, in-process)

- **IAEA inspections**: to verify the State declaration
  - examine operator records and reports
  - identify and count items
  - sample and assay nuclear materials
    - destructive analysis
    - non-destructive analysis

- **Containment and surveillance measures**: complement material accountancy
  - seals
  - cameras
Tools and Techniques

- Destructive Analysis
- Nondestructive Analysis
- Containment and Surveillance
- Environmental Sampling
- Open Source Information Collection and Analysis
Destructive Analysis (DA)

- Quantitative methods for determining elemental composition, elemental assay, or isotopic composition of a sample
- All or part of the sample is consumed in analysis
  - Sample cannot be recovered (e.g., it is volatilized)
- Sample is irreversibly altered
  - Dissolved
  - Radiochemically purified
- Does not necessarily mean important sample attributes are destroyed
  - Analyte separated from matrix, but preserved
Nuclear Material Laboratory (NML)

Groundbreaking

7 September 2011

On-Schedule – On-Budget

Inauguration

23 September 2013
Detection of gamma radiation is used in a variety of nuclear material measurements
Gamma Ray Spectroscopy - Detectors

**Sodium Iodide** (scintillator) – short count times (efficient), low resolution

**Germanium** (semi conductor) – large crystals, excellent resolution
- required a dewar of liquid nitrogen
- now electronically cooled versions

**Cadmium Zinc Telluride** (semi conductor) – Small size, good resolution, room temperature expensive
Detector Resolution

FIG. 1. Comparison of high- and low-resolution gamma spectra.
Passive Non-Destructive Analysis (NDA)

- Most nuclear materials emit alpha particles, which then react locally to produce (single) neutrons
- Plutonium also fissions spontaneously, so it can simultaneously release *multiple* neutrons
- Coincidence counting identifies this fission neutron signal to assay plutonium

High Level Neutron Coincidence Counter
Calorimetry

- Used to measure heat from decay
- Used to measure Pu and tritium in large quantities
- Very precise
- Long measurement times
Spent Fuel Measurements – Cerenkov Viewing Device
Spent Fuel Measurements – Fork Detector

• Measures neutron and gamma activity
• Made for BWR, PWR and VVER fuel
Containment and Surveillance

- Continuity of Knowledge
  - When inspectors are not present at the facility
  - Tamper Indicating Seals
  - Surveillance Systems
Tamper Indicating Devices

Passive - Metal Seal

Active - VACOSS Seal

Passive - Glass Seal

Active - Remote Monitored Sealing Array
Surveillance
Attended and Unattended Monitoring

- **Attended:**
  - Portable instrumentation that is used during inspections to take measurements (e.g., multi-channel analyzer)
  - Large instruments that are installed in the facility but require inspector presence for operation (Fork detector)

- **Unattended**
  - Instrumentation that is installed in the field for continuous operation (e.g., radiation monitors, containment/surveillance equipment)
  - Integrated into systems that are capable of storing data
  - Provide the opportunity for remote monitoring
Environmental Sampling

- Primary means for detecting clandestine or undeclared nuclear activities
- Inspectors collect samples
- Samples are evaluated, separated, archived and distributed for analysis
- Analysis conducted by the Network of Analytical Laboratories

Sampling Kit

IAEA Clean Laboratory at the Seibersdorf Analytical Lab
Environmental Sampling

Sampling Kit

Seibersdorf Analytical Lab
Open Source Information Collection and Analysis

- Uses all unclassified sources of information
  - Newspapers
  - Internet
  - Scientific publications
- Important means of detecting undeclared activities
- Information systems collect, analyze and organize information
- Compared to declarations and data collected in the field to draw conclusions
Open Source Information Collection and Analysis
Commercial Satellite Imagery

- Provides ability to perform broad area searches in instances where exact location information may not exist – but this is difficult
- High resolution – permits detailed analysis of facility infrastructure
- Change detection – detect even subtle changes in suspect facility

Natanz Enrichment Facility (Iran)

20 September 2002

29 February 2004
Interested in learning more?

BNL’s Safeguards Textbook

*Deterring Nuclear Proliferation: The Important of IAEA Safeguards*

by Michael D. Rosenthal

Available for download, free, from –

Opportunities in IAEA Safeguards

IAEA:

- Regular staff positions
- Cost Free Experts
- Junior Professional Officers
JPOs

- JPOs are entry-level employees that obtain professional experience while performing essential safeguards duties
- Two to three year assignments
- Assignments are based on official IAEA requests that are advertised on the ISPO website

www.bnl.gov/ispo
Objectives

- Introduce a new generation to international civil service and the nuclear industry
- Create entry level positions for students and recent graduates to obtain work experience
  - Stepping stone to regular staff or temporary assignments with the IAEA and positions in the U.S. national laboratories and government agencies
- Assist IAEA with basic yet essential work
Specific JPO Requirements

- U.S. citizens or permanent resident aliens
- Degree in relevant field
- 0-2 years work experience
- Less than 32 years of age
- Availability for at least one year
- Ability to work independently
Living and Working in Vienna

- Vienna is a culturally rich city
- Very safe - Low crime
- Working language is English
- Excellent public transportation
- Maintain American citizenship
Information on JPO Positions

- Website of the International Safeguards Project Office (ISPO)
  - www.bnl.gov/ispo
  - Sign up for job alerts – be informed when new jobs open
  - Get assistance in strengthening your application
Opportunities in the United States

- Internships
- Short courses
- Graduate Fellowships
Internships

- Available through all DOE national laboratories
- Undergraduate and graduate
- All areas of research, including safeguards
- At BNL
  - Stipends and housing provided
  - Participation in Intern Symposium
  - Publications possible
Tuition-Free Short Courses

- Nuclear Nonproliferation, Safeguards and Security in the 21st Century
  - Conducted at BNL
  - Delivered by internationally-recognized experts
  - For graduate students in technical and policy programs
  - Housing and need-based stipend provided
  - Find information at [https://www.bnl.gov/nnsscourse/](https://www.bnl.gov/nnsscourse/)

- 2020 Course will be held virtually August 3-14
Nonproliferation Graduate Fellowships

- Sponsored by National Nuclear Security Administration
- Managed by Pacific Northwest National Laboratory
- Assignments available in multiple U.S. government agencies
- For students or recent graduates in engineering, science, nuclear nonproliferation, international affairs, security, emergency operations, and other related disciplines
- Highly competitive; highly respected
- Excellent entree into U.S. government service
- Find information at https://nnsa.energy.gov/federalemployment/ourjobs/graduateprogram
Thank You!

Questions?