Introduction to Nuclear Safeguards Training

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LLNL-INL Safeguards Training Program

June 11, 2009
Quick Acknowledgements

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- Special thanks to our presenters:
  - Mary Adamic, INL
  - Robert Bean, INL
  - Adam Bernstein, LLNL
  - David Chichester, INL
  - Bill Domke, LLNL
  - Arden Dougan, LLNL
  - Casey Durst, DNE-INL
  - Jonathan Essner, LLNL
  - John Luke, LLNL
  - Richard Metcalf, INL
  - Mark Schanfein, INL
  - Ross Williams, LLNL
Overview

• Introduction to the Training
  – Purpose
  – Lecturers
  – Topics to be covered
• Introduction to Nuclear Safeguards
  – Definitions
  – The International Atomic Energy Agency
  – Introduction to Safeguards Methods
• Review
LLNL-INL Safeguards Training

• Series of lectures designed to bring the incoming professional or student to a “baseline” of understanding

• Presented by professionals who are specialized in the fields from Lawrence Livermore National Laboratory and Idaho National Laboratory

• Designed to become a recurrent training program offered each summer for the intern communities in the Department of Energy (DOE) complex
Purpose of LLNL-INL-STP

• Students must be able to understand the major issues in nuclear safeguards
  – Specific vernacular of safeguards
  – Legal basis for nuclear safeguards and security
  – Introduction to the IAEA
  – Common techniques for safeguards
  – Emerging techniques for safeguards
  – Historical and modern challenges in safeguards
  – Interaction of safeguards with other methods of protecting special nuclear material
Lecturers of the Training

• INL: Robert Bean, Mary Adamic, Mark Schanfein, Casey Durst, David Chichester, Richard Metcalf

Topic list of LLNL-INL-STP

- Thursday, June 11  Introduction to Nuclear Safeguards
- Tuesday, June 16  The Nuclear Fuel Cycle
- Thursday, June 18  International Safeguards Systems, Science & Technical Challenges
- Tuesday, June 23  A Day in the Life of an Inspector
- Thursday, June 25  Material Control and Accounting
- Tuesday, June 30  Destructive Analysis Methods
- Thursday, July 2   Nondestructive Analysis Methods
<table>
<thead>
<tr>
<th>Date/Week</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Tuesday, July 7</td>
<td>Passive &amp; Active Interrogation</td>
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<td>Thursday, July 9</td>
<td>Environmental Sampling</td>
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<td>Week of July 13</td>
<td>INMM</td>
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<td>Tuesday, July 21</td>
<td>Advanced Safeguards Approaches</td>
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<td>Thursday, July 23</td>
<td>Statistics and Safeguards &amp; Basic Process Monitoring</td>
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<td>Tuesday, July 28</td>
<td>The Story of Proliferation</td>
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<td>Tuesday, August 4</td>
<td>Open-Source Information: Collection and Analysis</td>
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Definitions and Terminology of Safeguards

• Nuclear Safeguards: measures to verify that civil nuclear facilities are not being misused to pursue weapons and associated materials are properly accounted for and are not diverted to undeclared uses
  – This is the operating definition that will be used by the majority of lecturers of this group.
  – Domestic safeguards (in-country, specifically in-USA) refers to traditional safeguards (above) as well as physical security measures.
  – Note that safeguards are a method of verification: safeguards are not designed to prevent the diversion of material but rather to identify that it occurred and therefore prevent by deterring.
Definitions and Terminology, cont.

• Physical security: measures to prevent the theft of nuclear material
  – Sometimes called “Guards, Gates, and Guns”
  – A country cannot “steal” from itself. Physical security prevents insiders and external threats from stealing material from a facility.

• International Safeguards: Safeguards as described previously, administered by the International Atomic Energy Agency
Definitions and Terminology, cont.

- **Significant Quantity:** The approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded.

- Includes machining assumptions not discussed here
  - The basic “unit” for international (IAEA) safeguards.

Information about SQs can be found on IAEA.org and the IAEA safeguards glossary, as well as their existing technical documents.

<table>
<thead>
<tr>
<th>Material</th>
<th>SQ</th>
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<tr>
<td>Direct use nuclear material</td>
<td></td>
</tr>
<tr>
<td>Pu(^a)</td>
<td>8 kg Pu</td>
</tr>
<tr>
<td>(233)U</td>
<td>8 kg (^{233})U</td>
</tr>
<tr>
<td>HEU ((^{235})U (\geq 20%))</td>
<td>25 kg (^{235})U</td>
</tr>
<tr>
<td>Indirect use nuclear material</td>
<td></td>
</tr>
<tr>
<td>(U (^{235})U &lt; 20%)(^b)</td>
<td>75 kg (^{235})U (or 10 t natural U or 20 t depleted U)</td>
</tr>
<tr>
<td>Th</td>
<td>20 t Th</td>
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</tbody>
</table>

\(^a\) For Pu containing less than 80\% \(^{235}\)Pu.
\(^b\) Including low enriched, natural and depleted uranium.
Definitions and Terminology, cont.

• Special Nuclear Material: nuclear material which can be made into a nuclear explosive device
  – In common nomenclature: Highly Enriched Uranium and Plutonium

• Highly Enriched Uranium: Uranium with 20% or greater U-235

• Timeliness Goal: Amount of time that the International Atomic Energy Agency has to detect a diversion of material
  – Related to the “latency” between diversion and weaponization of the material
  – More on this later
Definitions and Terminology, cont.

• The Treaty on the Non-Proliferation of Nuclear Weapons (NPT): the legal basis for international safeguards, obligating signatories to the international safeguards regime
  – The NPT entered-into-force on March 5, 1970
  – Nuclear-Weapon State (NWS), identified as states which had manufactured and exploded a nuclear explosive device prior to January 1, 1967, are required not to assist or encourage Non-Nuclear-Weapon States, in any way, to acquire a nuclear explosive device(s)
  – Non-Nuclear-Weapon State (NNWS) are required
    - Not to manufacture or otherwise seek to acquire a nuclear explosive device(s)
    - To accept safeguards, under an agreement with the IAEA, on all nuclear material in all peaceful activities
Definitions and Terminology

• Information Circular #153 (INFCIRC153): The basic safeguards framework that is in common use with all NPT signatories.

• Additional Protocol: An addition to the basic safeguards suite which gives greatly expanded powers to the IAEA.

• State System of Accounting and Control (SSAC): the state’s system of determining where all of their nuclear material is at the time of a declaration.

• Material Unaccounted For (MUF): Material that is not accounted for by the current measurements. This does not mean it is diverted, as it could be stuck in pipes or otherwise still in the facility.

• Declaration: A formal reporting of material or operations in a facility to the International Atomic Energy Agency.
The International Atomic Energy Agency

• The primary safeguards system in use today is the International Safeguards System of the International Atomic Energy Agency (IAEA)
  – other safeguard systems exist such as the U.S. Nuclear Regulatory Commission (NRC) Safeguards and Security System and Euratom Safeguards, which are often more rigorous

• While these other safeguard systems are important, due to time constraints we will focus only on the IAEA (international) safeguards system
The International Atomic Energy Agency

- Created in 1957 by the United Nations General Assembly
- 138 Member States (MS)
- 2247 Professionals and Support Staff
- 274 M.US$ → Regular Budget 2006
- 77.5 M.US$ → Technical Cooperation Fund
- About 51 M.US$ → Extra budgetary
- Reports to: United Nations General Assembly (annually), United Nations Security Council (when appropriate), United Nations Economic & Social Council
The IAEA Board of Governors
The International Atomic Energy Agency

• Three primary missions:
  – Promotion of peaceful uses of nuclear energy
  – Develop nuclear safety and security standards, promoting high levels in both as well as the protection of people and the environment.
  – Application of Safeguards
    • The IAEA verifies correctness of a state’s declaration to provide assurance on the non-diversion of declared nuclear material;
    • Verifies completeness of a state’s declarations to provide credible assurance on the absence of undeclared nuclear material and activities.
Safeguards Agreements

- An agreement for the application of safeguards concluded between the IAEA and a State or a group of States
  - in certain cases, with a regional or bilateral inspectorate, such as Euratom and ABACC (South American, Argentina-Brazil)
  - agreement is concluded either because
    - of the requirements of a project and supply agreement
    - to satisfy the relevant requirements of bilateral or multilateral arrangements
    - at the request of a State to any of that State’s nuclear activities
  - Each State’s agreement is different.
    - But there are some commonalities, based on type
Non-Compliance

• Violation by a State of its safeguards agreement with the IAEA. For example:
  – the diversion of nuclear material from declared nuclear activities
  – the failure to declare nuclear material required to be placed under safeguards
  – under an additional protocol, the failure to declare nuclear material, nuclear activities, or nuclear related activities required to be declared
  – violation of the agreed recording and reporting system
  – obstruction of the activities of IAEA inspectors
  – interference with the operation of safeguards equipment

• if non-compliance, the IAEA Director General shall report to the IAEA Board of Governors
  – which would call upon the recipient State to remedy any non-compliance
  – There are historical, and current, cases where the State has ejected IAEA inspectors.
International Atomic Energy Agency

• Everyone presenting in this series helps support the IAEA through our research.

• Ensuring that all countries around the world are not diverting material or misusing facilities or working with hidden facilities on a constrained budget is not a trivial task
  – Also, that diversion can be, in some cases, less than 0.1% of a facility’s material handling,
  – And States can actively block your inspections, or bulldoze sites before you can inspect them,
  – With a requirement for almost total transparency to the international community.
Safeguards Methods

- Safeguards are executed in several ways
  - Before a facility is built, information about the facility is given to the IAEA on a Design Information Questionnaire
    - The DIQ is part of a larger group of measures in Design Information Verification to ensure facilities are built and operated as designed
    - The DIQ is used to help build the safeguards approach, which is negotiated and added to the safeguards agreement
Safeguards Methods

• The safeguards approach can include several different types of IAEA systems
• These systems fall into several typical categories
  – Tamper Indicating Devices (Seals)
  – Containment and Surveillance (Cameras)
  – Radiation Monitors (Nondestructive Analysis)
    • Can be passive (receiving) or active (emitting)
  – Very small nuclear materials sampling (Destructive Analysis)
  – Swipe samples from the environment
  – Process Monitoring systems to watch the operating parameters of a chemical process
  – Advanced Systems
Tamper Indicating Devices (TIDs)

- TIDS are seals that the agency uses on its cabinets as well as storage casks and other areas for which little to no movement is expected.
- These can be fiber optic, metal, plastic, and come in varied shapes, sizes, and types.
Containment and Surveillance (C/S)

- Containment and surveillance is the use of observations (often qualitative) as part of the safeguards suite.
- The Agency relies heavily on containment and surveillance in many modern facilities as part of the safeguards approach.
- The C/S systems are quite robust, but automated analysis remains a challenge because of data overload.
Nondestructive Analysis

• Either simply listens, or evokes an echo from material to garner signals without destroying any amount of the material or requiring a sample

• These systems will be explained in more detail by David Chichester in a following lecture
Destructive Analysis

- Requires a small sample pulled from the item or process that you are measuring
- Typically more accurate, but slower, than NDA
- DA is the “workhorse” of most safeguards approaches
- Mary Adamic will present a lecture on this in more detail
Environmental Sampling

- Nuclear material processes do release very trace amounts of materials into the environment.
- Analysis of environmental samples can reveal the presence of undeclared activity.
- Ross Williams will lecture on this topic on a later date.
Process Monitoring

• By watching chemical process information, as well as online NDA, diversions can be detected
• Watching the process helps give a first pass as to anomalies that may be occurring, and the recorded data can lead inspectors to a potential problem
• I will lecture about this topic at a later date
In Review

• International Safeguards exists to prevent the use of nuclear materials for weapons purposes
• It is given legal authority by the Nonproliferation Treaty (NPT)
• The International Atomic Energy Agency is the international inspectorate, which uses several methods to ensure that
  – Facilities are not diverting material
  – There are no other facilities than those declared
Next Time

• Adam Bernstein will present an overview of the nuclear fuel cycle