Title: Terminating Safeguards on Excess Special Nuclear Material: Defense TRU Waste Clean-up and Nonproliferation

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Terminating Safeguards on Excess Special Nuclear Material: Defense TRU waste Clean-up and Nonproliferation

Tim Hayes, Los Alamos National Laboratory, Carlsbad Operations
Roger Nelson, Department Of Energy, Carlsbad Operations Office
U. S. Nuclear Weapons Stockpile, 1945-2009

From DOE Fact Sheet: Increasing Transparency in the U.S. Nuclear Weapons Stockpile, May 3, 2010
NNSA Weapons Complex Transformation

PRESENT FACILITIES

FUTURE CONSOLIDATED AND MODERNIZED FACILITIES

FOOTPRINT: > 35 MILLION SQUARE FEET FOR WEAPONS WORK

FOOTPRINT: < 26 MILLION SQUARE FEET FOR WEAPONS WORK

DENOTES SITE WITH SPECIAL NUCLEAR MATERIALS REQUIRING HIGHEST LEVELS OF SECURITY

KEY

- Nuclear Design & Engineering
- Non-Nuclear Design & Engineering
- Supercomputing Platform Host
- Major Environmental Testing
- High Hazard Testing
- Tritium Operations
- Uranium
- Plutonium
- Weapons Assembly & Disassembly
- Non-Nuclear Production

* Does not include production of detonators at LANL or neutron generators and microelectronics at SNL

What is excess SNM?

• SNM = Special Nuclear Material
  – Plutonium
  – Uranium-233
  – Enriched uranium

  Fissionable materials that could be used to manufacture nuclear weapons

• Excess
  – Fissile materials declared permanently withdrawn from:
    • use in nuclear weapons
    • use in national security weapons-related activities.
  – Nuclear materials that are no longer needed to support current or future national security requirements.

• Excess ≠ Waste
What is surplus SNM?

• Surplus SNM is Excess plus no DOE programmatic use

• Disposition - make “non-weapons-usable”
  – Consumption in DOE or non-DOE programs
  – Storage in a non-weapons usable form
  – Disposal as waste

• Disposal as waste
  – Assures isolation from the biosphere
  – Little or no maintenance
  – Little or no intent of retrieval
  – Requires deliberate and detectable action to gain access after emplacement
Disposal of Excess-No Programmatic SNM

- WIPP Mission – Defense TRU waste disposal
  - Usually contains Pu
  - Does not require SNM safeguards
  - Final waste form must have safeguards terminated at the generating site
Understanding Safeguards Termination

• Basis of Graded Safeguards of SNM
  - Attractiveness
    • Reflects the relative ease of processing and handling required to convert that material to a nuclear explosive device
    • Not affected by how the material is stored or packaged
  - Category
    • A designation that is based on the attractiveness and amount of material

• Category is used to identify the level of protection at the site

• All materials coming to WIPP have safeguards terminated
## Graded Safeguards

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>WEAPONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembled weapons and test devices</td>
<td>A</td>
<td>All</td>
<td>N/A</td>
</tr>
<tr>
<td>PURE PRODUCTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pits, major components, button ingots, recastable metal, directly convertible materials</td>
<td>B</td>
<td>≥2</td>
<td>≥0.4&lt;2</td>
</tr>
<tr>
<td>HIGH-GRADE MATERIALS</td>
<td></td>
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</tr>
<tr>
<td>Carbides, oxides, nitrates, solutions (≥25g/L) etc.; fuel elements and assemblies; alloys and mixtures; UF₄ or UF₆ (≥50% enriched)</td>
<td>C</td>
<td>≥6</td>
<td>≥2&lt;6</td>
</tr>
<tr>
<td>LOW-GRADE MATERIALS</td>
<td></td>
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<tr>
<td>Solutions (1 to 25 g/L), process residues requiring extensive reprocessing; Pu-238 (except waste); UF₄ or UF₆ (≥20% &lt; 50% enriched)</td>
<td>D</td>
<td>N/A</td>
<td>≥16</td>
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<tr>
<td>ALL OTHER MATERIALS</td>
<td></td>
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</tr>
<tr>
<td>Highly irradiated² forms, solutions (&lt;1g/L), compounds; uranium containing &lt;20% U-235 or &lt;10% U-23³³^(any form, any quantity)</td>
<td>E</td>
<td>N/A</td>
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¹The lower limit for Category IV is equal to reportable quantities in this Order.

²The total quantity of U-233 = (Contained U-233 - Contained U-235). The category is determined by using the Pu/U-233 side of this table.

³In this Order "highly irradiated is defined in Attachment 4(Definitions).
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Figure 1-1. Decision tree for determination of material attractiveness level for special nuclear material.
Four conditions for Termination of Safeguards

1. Excess and of no programmatic value
2. Meets attractiveness level E or has obtained approval to terminate safeguards
3. Transferred to a waste management reporting identification symbol
4. Not collocated with materials which are still in the accountability system for safeguarded materials

Reminder: Attractiveness Level is associated with the properties of the material not how it is stored or packaged.
Termination of Safeguards

Attractiveness Level D material

- Attractiveness Level D: Low Grade Materials
  - Residues requiring extensive reprocessing
  - Pu-238 that is not waste

- Blend or Process to Attractiveness Level E
  - Expensive
  - Large increase in volume

- Perform a Security Analysis to assess risk
  - Most sites have done this successfully
    - Uniform waste acceptance for WIPP
    - Waste acceptance not Attractiveness dependant
  - Does not significantly increase of adversarial actions
    - Theft of a Category II quantity
    - Radiological Sabotage
Termination of Safeguards
Attractiveness Level C material

• Attractiveness Level C: High Grade Materials
  – Carbides, oxides, nitrates, fuel elements, alloys, mixtures

• Blend with chemical compounds to reduce the attractiveness to Level D
  – Reduce plutonium solubility
  – Decrease recovery efficiency
  – Increase processing complexity
Blending materials

- Concept developed and tested at RFP called "Stardust"
- Chemical additives by property
  - Cementing agents
  - Gelling agents
  - Thickening agents
  - Foaming agents
  - General additives
- Can be tailored to match the physical properties of the attractiveness C material
- Usually blend down to less than 10% Pu in the final form.
Termination of Safeguards
Attractiveness Level B material

• Attractiveness Level B: Pure Materials
  – Pits, button ingots, re-castable metal, directly convertible materials

• Most likely disposition is not discard
  – MOX (to be consumed)

• Discard
  – Oxidize (making it attractiveness level B)
  – Blend with chemical compounds to reduce the attractiveness to Level D
Packaging for WIPP - POC

- Currently limited to 200 Pu-239 Fissile Gram Equivalents
  - Typical weapons grade Pu (MT 52) is 0.94 Pu-239 FGE/g Pu
  - Add 2 times the measurement uncertainty
  - 150 - 175 g Pu per container
  - 35 in a shipment
Criticality Control Overpack

- ~380 Pu-239 FGE
  - 2 times the uncertainty
- 70% cost of POC
- 42 per shipment
- Only in 6 inch