REQUIREMENTS FOR THE TRANSPORT OF SURPLUS FISSIONE MATERIALS IN THE UNITED STATES

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ABSTRACT

This paper discusses the requirements and issues associated with the transportation of surplus fissile materials in the United States. The paper describes the materials that will be transported, the permissible modes of transport for these materials, and the safety and security requirements for each mode of transport. The paper also identifies transportation issues associated with these requirements, including the differences in requirements corresponding to who owns the material and whether the transport is on-site or off-site. Finally, the paper provides a discussion that suggests that by adopting the spent fuel standard and stored weapon standard proposed by the National Academy of Sciences, the requirements for transportation become straightforward.

INTRODUCTION

The United States Department of Energy (DOE) has undertaken a program to evaluate and select options for the disposition of fissile materials declared surplus to defense needs as a result of the end of the Cold War. The process begins with pit disassembly and conversion, and plutonium conversion and stabilization. With this "front end" the disposition options being considered include immobilization (with and without high level waste), MOX fuel fabrication (with subsequent use in CANDU reactors in Canada or light water reactors and advanced light water reactors in the U.S.). The disposition also includes the final disposition in deep boreholes or geologic repositories. These disposition options will all require the transportation of surplus fissile materials from their current locations to final disposition facilities. The flow paths for these options may involve several material forms and modes of transport for which different safety and security requirements apply.

The objective of this paper is to identify and contrast the specific regulations that may apply to the transport of different forms of surplus fissile materials, by different modes of transport, both on-site and off-site. The differences in transportation requirements may impact the environmental impact, feasibility, cost, and transparency of the disposition options being considered.

Material Ownership

The existing DOE and other federal requirements, Orders, and regulations governing transportation safety and security depend upon the "ownership" of the material; that is, whether the material is in the custody of DOE's Defense Programs (DP) or not. Historically, ownership of the materials has fallen into two groups. One group contains only one member -- the DOE's Defense Programs (DP). The other group contains non-Defense Programs such as the DOE's Nuclear Energy (NE) program or Environmental Restoration and Waste Management program (EM).

The group containing DP materials has included the more attractive materials from a theft and diversion standpoint (including most, if not all, weapon grade materials). These materials require the highest levels of security (i.e., they require transport by the DOE's Transportation Safeguards System) and safety (e.g., in some cases the DOE has precluded certain transportation options when risks were unnecessarily high). By contrast, the second group of non-DP materials consists mostly of lower-grade defense plutonium (e.g., reactor-grade plutonium, spent fuel). These materials are less attractive to theft or diversion and present a lower risk when shipped. Therefore, transport by the Transportation Safeguards System is not required (although not precluded if authorized by the DOE), and modes of transport other than Safe Secure Trailer (SST) are permissible (e.g., rail, air, water).

The Spent Fuel Standard and Stored Weapon Standard

A policy which assigns ownership of fissile material when it is declared surplus is being developed but has not been formalized. This paper will adopt the convention in which material meeting a proposed "spent fuel standard" will not need to be under DP custody, while materials meeting a "stored weapon standard" will remain under DP custody. The "stored weapon standard" and "spent fuel standard" are terms originally defined by the National Academy of Sciences in the report "Management and Disposition of Excess Weapons Plutonium" [1]. They are recommended as key criteria for judging disposition options, and reflect the security
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necessary to minimize the proliferation risks due to theft and diversion. Under this convention, existing federal transportation safety and security requirements can be applied to the disposition options.

Spent Fuel Standard

The Spent Fuel Standard was designed to define a level of inaccessibility desired for surplus fissile materials and was based on material form, location and institutional regulations and requirements. However, for the purposes of the Fissile Material Disposition Program and this paper, the Spent Fuel Standard is equated with the intrinsic properties or the form of the material only [2]. By doing so, judgments can be made to determine whether the (processed) material has an equivalent nature as spent fuel. It is important to note, however, that this definition should not be confused with the definition of spent fuel. The purpose of defining a spent fuel standard is to provide guidance on which materials can be placed under those safeguards and security procedures that currently apply to spent fuel.

The spent fuel standard consists of the radiological, physical, chemical and nuclear properties or characteristics of a disposition option that make processed excess weapons plutonium as inaccessible for recovery as commercial spent fuel. The radiological, physical, and chemical characteristics must be met for a material to fall under the spent fuel standard. The nuclear properties have only a secondary effect. The details of the radiological, physical and chemical requirements can be found in reference 2.

Stored Weapon Standard

The Stored Weapon Standard (Appendix A of [2]) consists of four different components: material form, attractiveness level, protection principles, and security concept. The material form can provide some proliferation resistance. The form reflects the intrinsic properties of materials which determine their attractiveness for use in nuclear weapons. There is believed to be a correlation between materials with low attractiveness levels for weapons use and proliferation resistance and, therefore, lesser requirements for safeguards and security. Materials with high levels of attractiveness for use in nuclear weapons have significant safety and security requirements. The four components of the stored weapon standard are discussed in greater detail in the following sections.

Note on the Scope of this Paper

This paper is limited to a discussion of requirements for DOE materials. Materials at DOE contractor facilities and other facilities licensed by the NRC come under federal regulations such as 10 CFR Part 71 and 49 CFR Parts 100 - 189.

MATERIAL CATEGORIES AND ATTRACTIVENESS

Requirements for the control and accountability of nuclear materials, including transportation situations, are generally based on the category of material and its attractiveness. DOE Order 5633.3B [3] defines requirements for the control and accountability of nuclear material. Table I-2 in DOE Order 5633.3B defines the four safeguards categories for special nuclear materials. Table 1, below, shows the portion of Table I-2 pertaining to plutonium. As the Table shows, there are four categories of material, numbered I through IV, for each of the five attractiveness levels. Materials meeting the spent fuel standard will likely fall into attractiveness level E, and are thus, by definition, all category IV materials. Using the convention described above, these materials could be transferred from Defense Programs’ custody to the custody of another DOE program.

Other forms of surplus fissile material meeting the stored weapon standard will fall into other attractiveness levels, perhaps as high as level B in the case of surplus pits. Under the convention discussed earlier, these materials would remain in DP custody.

IAEA Categories

Since the material declared surplus to defense needs will be placed under IAEA safeguards, it is worth noting that the IAEA also has established categories of nuclear material. Table 2 shows the categorization of plutonium. Tables 1 and 2 result in consistent safety and security requirements for transportation. [4].
Table 1. (DOE) Nuclear Material Safeguards Categories for Plutonium

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Attractiveness Level</th>
<th>Category I (Quantities in Kgs)</th>
<th>Category II (Quantities in Kgs)</th>
<th>Category III (Quantities in Kgs)</th>
<th>Category IVa (Quantities in Kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEAPONS</td>
<td>A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>PURPLE PRODUCTS</td>
<td>B</td>
<td>≥ 2</td>
<td>≥ 0.4 &lt; 2</td>
<td>≥ 0.2 &lt; 0.4</td>
<td>&lt; 0.2</td>
</tr>
<tr>
<td>HIGH-GRADE MATERIAL</td>
<td>C</td>
<td>≥ 6</td>
<td>≥ 2 &lt; 6</td>
<td>≥ 0.4 &lt; 2</td>
<td>&lt; 0.4</td>
</tr>
<tr>
<td>LOW-GRADE MATERIAL</td>
<td>D</td>
<td>N/A</td>
<td>≥ 16</td>
<td>≥ 3 &lt; 16</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>ALL OTHER MATERIAL</td>
<td>E</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Reportable Quantities</td>
</tr>
</tbody>
</table>

a/ The lower limit for category IV is equal to reportable limits in this Order.

Table 2. IAEA Categorization of Plutonium

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Category I</th>
<th>Category II</th>
<th>Category III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plutonium</td>
<td>Unirradiated</td>
<td>≥ 2 kg</td>
<td>≥ 500 g &lt; 2 kg</td>
<td>≥ 15 g &lt; 500 g</td>
</tr>
</tbody>
</table>

Notes: a/All plutonium except that with isotopic concentrations exceeding 80% in plutonium-238; b/Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 100 rads/hour at one meter unshielded; c/Quantities not falling into Category III and natural uranium should be protected in accordance with prudent management practice.

MODES OF TRANSPORT
Determining the permissible modes of transport for surplus fissile materials can be determined first on the basis of security requirements and, second, by considering operational issues (e.g., will the cargo fit in the conveyance). Safety does not, strictly speaking, dictate the mode of transport. In some cases, the DOE could preclude certain modes of transport. For example, the Department unilaterally decided to suspend the use of both rail and air modes to transport nuclear explosives, as they were deemed either unnecessary or unnecessarily high in risk. In other cases, the packaging required for safety may preclude certain modes of transport. For example, some spent fuel shipping casks are too large to fit inside the Safe Secure Trailer (SST) used by the DOE’s Transportation Safeguards Division (TSD) for highway shipments.

ON-SITE VERSUS OFF-SITE TRANSPORT
As will be shown, the definitions of on-site and off-site transport are important because of the requirements for transportation that apply for safety and security. The levels of safety and security are no different; however, the applicable regulations are. DOE Order 5610.12 [5] defines off-site as “areas outside the boundaries and jurisdiction of a DOE facility to which the general public has free and unlimited access.” DOE Order 5480.X [6] defines on-site as “any area within the boundaries of a
DOE site or facility that is fenced or otherwise accessed-controlled.”

SECURITY

The applicable regulations for determining security requirements are defined in Chapter II of DOE Order 5632.1C [7] and DOE M 5632.1C-1 [8]. Table 3 summarizes the conditions under which transport under the control of the DOE’s Transportation Safeguards System (TSS) is and is not required.

IAEA Requirements

The existing DOE requirements for transportation security are consistent with the requirements of the IAEA, as agreed to in the Convention on the Physical Protection of Nuclear Material which “obligates parties to make specific arrangements and meet defined standards of physical protection for international shipments of nuclear material” [9]. In general, the U.S. requirements are as restrictive or more so than IAEA requirements. For example, the DOE currently does not permit the rail shipment of Category I materials while the IAEA regulations do. While the IAEA requirements are not a significant issue for domestic shipments of surplus fissile materials, it is important for those that could transit between two nations (e.g., the shipment of fresh MOX fuel from the United States to Canada).

<table>
<thead>
<tr>
<th>Material Category</th>
<th>Requirement for TSS?</th>
<th>Permissible Modes of Off-Site Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On-Site</td>
<td>Off-Site</td>
</tr>
<tr>
<td>I</td>
<td>NO a</td>
<td>TSS Required</td>
</tr>
<tr>
<td>II</td>
<td>NO a</td>
<td>TSS Required</td>
</tr>
<tr>
<td>III</td>
<td>NO b</td>
<td>TSS “may” be required c</td>
</tr>
<tr>
<td>IV</td>
<td>NO b</td>
<td>TSS “may” be used c</td>
</tr>
</tbody>
</table>

NOTES:

- a/ This table does not address nuclear weapons, subassemblies or other nuclear explosives. The DOE addresses the protection of unclassified irradiated reactor fuel separately in Chapter IV of DOE 5632.1C and DOE M 5632.1C-1, and does not require shipment by SST. This begs the question regarding the shipments of classified forms of irradiated fuel. As noted in Chapter II, Paragraph 1(e), “when special nuclear material is classified because of its configuration or content, or because it is part of a classified item, it shall receive the physical protection required by the highest level of classification of the configuration, content, or item, or category of special nuclear material involved, whichever is greater.”
- b/ Transport by water is not specifically addressed, most likely because situations involving domestic shipments by water are not likely to arise.
- c/ Shipment by TSS is not required; however, “Protection measures for movements of material between protected areas at the same site, or between protected areas and staging areas at the same site, shall be under direct surveillance by the number of Security Police Officers necessary to protect against threats as established in the Department’s threat policy.”
- d/ DOE M 5632.1C-1 provides specific requirements for shipments of unclassified configurations.
- e/ “Domestic offsite shipments of classified configurations ... may be made by the TSS.” Unclassified shipments do not require shipment by TSS.
- f/ “Air shipments ... may take place if not otherwise prohibited by statute or otherwise limited by implementing instructions.”
- g/ Transport is only discussed for unclassified configurations.
- h/ Although not specifically addressed, TSD does not currently possess the resources for conducting transport over water.
- i/ As noted earlier, the DOE unilaterally suspended the use of rail shipments for nuclear explosives by rail and air as being unnecessary or unnecessarily high in risk.

SAFETY REQUIREMENTS

As shown in Table 4, for off-site shipments made by TSS, procedures are proscribed in implementing orders for DOE Transportation Safeguards Division (TSD) operations. If shipment by the TSS is not required, then a plan will have to be provided by the transporting organization and approved by the DOE.

For on-site transport, there are no specific DOE orders when transport is by TSS, since such shipments typically do not occur (i.e., on-site shipments are handled by the...
facility in facility vehicles). For on-site shipments of weapon grade materials, nuclear components, special assemblies, test subassemblies, and parts, safety precautions are determined on a facility basis and recorded in the master safeguards and security study for that facility. For hazardous materials, hazardous substances, and hazardous wastes, (Draft) DOE Order 5480.X [10] has been circulated which defines the requirements for on-site transport. On-site transport must comply with the Department of Transportation Hazardous Materials Regulations (i.e., 49 CFR 170-189) or the site-specific requirements that incorporate containment, communication, and control measures. 5480.X proscribes minimum requirements.

Table 4. Safety Requirements for On-Site and Off-Site Transport

<table>
<thead>
<tr>
<th>TSS Shipments</th>
<th>ON-SITE</th>
<th>OFF-SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS is typically not used for on-site shipments</td>
<td>DOE order 5480.3 or 5610.12 applies, depending on material type. DOE Order 5510.12 applies to nuclear components, special assemblies, and radioactive materials associated with the nuclear weapons program; DOE Order 5480.3 applies to hazardous material, hazardous substances, and hazardous waste; i.e., non-DP hazardous shipments.</td>
<td></td>
</tr>
</tbody>
</table>

| Non-TSS Shipments | DOE 5480.X applies for certain materials. For materials not meeting the scope of 5480.X, the requirements in 49 CFR 170-189 apply. | Non-TSS shipments must meet requirements of Title 10 CFR, Part 71 and Title 49 CFR, Parts 107-189, which provide regulations and procedures for the shipment of radioactive and hazardous materials, respectively. |

Although Title 49 CFR Part 173.7(b) provides the so-called national security exemption from the regulations in Parts 170-189 of Title 49 for “shipments of radioactive materials, made by or under the direction or supervision of the Department of Energy or the Department of Defense, and which are escorted by personnel specifically designated by, or under the authority of those agencies, for the purpose of national security”, it remains the DOE’s policy to comply with all DOT over-the-road requirements for which no overriding safety or security imperative exists. As noted in 49 CFR 173.7(d), “notwithstanding the requirements of §§ 173.416 and 173.417 of this subchapter, packagings made by or under the direction of the U.S. Department of Energy may be used for the transportation of radioactive materials when evaluated, approved, and certified by the Department of Energy against packaging standards equivalent to those specified in 10 CFR Part 71. Packages shipped in accordance with this paragraph shall be marked or otherwise prepared for shipment in a manner equivalent to that required by this subchapter for packagings approved by the Nuclear Regulatory Commission.”

SUMMARY AND CONCLUSIONS

Surplus fissile material shipments will be required to meet transportation safety and security requirements. The particular requirements will depend on the form of the material (which translates into attractiveness levels and safeguards categories) and whether the shipments occur on-site or off-site. Historically, ownership of the materials has fallen into two categories: Defense Program (DP) materials and non-Defense Program (non-DP) materials. DP materials have included forms falling into the higher attractiveness levels (including most, if not all, weapon grade materials) and thus comprise most of the materials in categories I-III. Materials in these attractiveness levels and categories require the highest levels of security (i.e., they require transport by the DOE’s Transportation Safeguards System) and safety (e.g., in some cases the DOE has precluded certain transportation options when risks were unnecessarily high).

By contrast, most lower-grade plutonium (e.g., reactor-grade plutonium, spent fuel) comprise non-DP material inventories. These materials fall into the lower
attractiveness levels (D and E) and rarely occur in a form that does not exceed category IV. Therefore, transport by the Transportation Safeguards System is not required (although not precluded if authorized by the DOE), and modes of transport other than Safe Secure Trailer (SST) are permissible (e.g., rail, air, water).

In their report on the management and disposition of excess weapons plutonium, the National Academy of Sciences recommended long-term disposal options to minimize the risks of non-proliferation by unauthorized parties and reconstitution of dismantled arsenals, while protecting worker and public health and the environment. Their discussion of security and safety occurred around the notions of the stored weapon standard for materials that were in storage or in process, and the spent fuel standard which would apply to materials after disposition was complete.

This report has embraced the concepts of a spent fuel standard and stored weapon standard as a means of simplifying the application of safety and security requirements to surplus fissile materials. It appears that the current levels of transportation safety and security would be met if all surplus fissile materials were placed in one of two categories: spent fuel standard materials and stored weapon standard materials. Those materials meeting the stored weapon standard would require transport by the TSS and would be required to meet packaging and transportation requirements defined in DOE Order 5610.12. At such time as the stored weapon standard materials were converted into unclassified forms meeting the spent fuel standard, the requirements for transportation would change. Shipment by TSS would not be required (although in some cases it might still be desirable), and packaging would conform to 10 CFR 71 standards.

Such a convention for categorizing surplus fissile materials and defining safety and security requirements would require a change in existing policy regarding the custody of surplus fissile materials. Many materials declared to be surplus are currently in DP custody, particularly the high-grade materials such as pits and pure metal. The only surplus materials not currently in DP custody (and thus in the custody of the DOE Nuclear Energy program or Environmental Restoration and Waste Management program) are low-grade materials such as residues that are difficult to recover, spent fuel, and waste. One option would be to place all materials meeting the spent fuel standard in the custody of a separate DOE program or office. This would permit effective monitoring and management, and contribute to the effective application of safety and security requirements for transportation.

REFERENCES

3. DOE Order 5633.3B, Subject: Control and Accountability of Nuclear Materials, Dated 9-7-94, Office of Safeguards and Security
5. DOE Order 5610.12, Packaging and Off-Site Transportation of Nuclear Components and Special Assemblies, associated with the Nuclear Weapons Program and Weapon Safety Program, Dated 7-26-94.
6. DOE Order 5480.X (Draft), Subject: On-Site Hazardous Materials Packaging and Transportation Safety, Dated: 11-12-94.
10. DOE Order 5480.X (Draft), Subject: Onsite Hazardous Materials Packaging and Transportation Safety, Dated: 11-12-94.

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