DEVELOPING HEU GUIDELINES [1]

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ABSTRACT

Programs to develop low-enriched uranium (LEU) fuels and targets, and convert research reactor and radioisotope production processes are based on a shared interest to minimize the use of highly enriched uranium (HEU). Many states have committed themselves to this work over the years, but an international mechanism codifying the objectives of HEU minimization or other policies related to the management of this material is lacking. With this in mind, the James Martin Center for Nonproliferation Studies is facilitating the drafting of HEU guidelines, modeled in part on the existing plutonium guidelines. This paper provides an overview of our work on guidelines, which include transparency measures, recommended security measures, rules on transport and international transfer, along with other relevant policies for safe and secure management of HEU. The adoption of voluntary guidelines is essential to help the global community agree on some norms in this area and ensure that programs like RERTR can meet future political challenges.

Introduction

The RERTR and related programs have worked to solve the technical challenges to reducing the use of highly enriched uranium (HEU) in the civilian sector for over 25 years. These programs were initiated as a result of the recognition of the dangers posed by HEU. While some technical difficulties remain, it is now clear that these issues are not the only, or even the main, impediment to further minimization of HEU use in the civilian sphere. Indeed, at the Technical Workshop on HEU Minimization held June 17-18, 2006, in Oslo, Norway, there was a broad consensus that conversion of research reactors and radioisotope production to LEU is technically feasible. However, not all states and all facilities worldwide have committed to exploring conversion possibilities.

While the minimization and eventual elimination of HEU use is the surest way to reduce the threat of theft and misuse of this material, finding the political will to realize this goal will take time. Until then, there will be civilian facilities employing HEU for some years to come. Therefore, it is important to ensure that HEU is managed in as safe and secure a manner as possible in the near term, while political support is gathered for further reductions in HEU use in the longer term.

With this in mind, the James Martin Center for Nonproliferation Studies (CNS) is leading an effort to draft HEU guidelines, modeled in part on the Guidelines for the Management of Plutonium (contained in INFCIRC/549 of 16 March 1998). There is interest at the IAEA, as well as among some individual member states, in the adoption of HEU guidelines. France, for example, called for the adoption of HEU guidelines at the 2007 Preparatory Committee meeting for the 2010 NPT Review Conference.[2] Both France and the United States have reportedly drafted language for HEU guidelines.

This paper will begin by providing an overview of the development and adoption of the plutonium guidelines, which form the basis for the HEU guidelines we are drafting together with a group of experts. Next, the paper will turn to the HEU guidelines draft itself, providing an overview of the elements that we are including and remaining questions regarding some of the details related to each issue: details that will have to be worked out in consultation with technical and policy experts knowledgeable in this field. Finally, it will briefly relate the process we foresee for promoting the voluntary adoption of these HEU guidelines, by states and non-state entities such as fuel cycle enterprises, to help ensure the safe and secure management of HEU.

The Development of Plutonium Guidelines

The plutonium guidelines were devised to provide an internationally accepted framework for the management of plutonium, reaffirming states' commitments to existing obligations undertaken within the NPT framework, renewing their commitment to formulate national strategies for plutonium management, making a new commitment to transparency, and providing for controls over international transfers.[3] The plutonium guidelines cover all plutonium in peaceful use, including material declared excess to defense needs. The commitment to publish occasional statements on national plutonium management strategies does not contain an objective to reduce plutonium use, but instead is meant to ensure that plutonium production, use, and holdings are the subject of a thoughtful and considered strategy, recognizing that there is no single solution appropriate for all states. The guidelines do, however, note the importance of having a balance of supply and demand for plutonium (although to date the guidelines are not being implemented on this important point).

Adoption of the plutonium guidelines is voluntary: they apply to all states that agree to be bound by their conditions and requirements. To date, only the nine states involved in drafting the guidelines have adhered to them, although several other states have separated plutonium, and all states using nuclear power have plutonium in spent fuel. There has not yet been an effort to engage additional countries in reporting their plutonium management strategies and holdings.

The plutonium guidelines were drafted by the so-called "plutonium group," a group of nine countries (the five nuclear weapon states, Japan, Germany, Belgium, and Switzerland) that have substantial programs in the separation or use of plutonium. The plutonium group discussions that led to the guidelines grew out of informal meetings at the IAEA in 1992 and 1993. The discussions were moved out of the Agency due to the belief that they would progress more quickly and effectively in a smaller, closed group, but the IAEA was kept closely informed of the progress of the talks. Once the group decided that individual countries ought to take responsibility for the information they produce with regards to plutonium strategies and holdings, it became clear that no new institutional role for the IAEA was required. However, the information on strategies and holdings, which was to take a standard format developed by the group, would be published by the IAEA as information circulars (INFCIRCs). [For information on the publication of such reports by states adhering to the plutonium guidelines, see Table 1, below.] While the standard format ensured that at least minimal information on plutonium inventories would be included in the declarations, it has been noted that the simplified format meant that earlier, detailed declarations that the United Kingdom had previously been publishing were curtailed to meet the new format, becoming somewhat less useful. Furthermore, not all

Table 1. Annual Reports of Civil Pu and HEU Holdings in Accordance with INFCIRC/549 [4]

For the year:	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Belgium	3	3/1	3/2	3/3	3/4	3/4	3/5	3/6	3/7		
China	7		7/1	7/2	7/2	7/2	7/3	7/4	7/5	7/6	7/7
France	5a	5/1	5/2	5/3 HEU 5/5	5/4 HEU 5/5	5/6 HEU	5/7 HEU	5/8 HEU	5/9 HEU	5/10 HEU	5/11 *
Germany	2/1	2/1	2/2	2/3	2/4 HEU	2/5 HEU	2/6 HEU	2/7 HEU	2/8 HEU	2/9 HEU	
Japan	1	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	
Russia	9 as of 6/96		9/1	9/2	9/3	9/4	9/5	9/6	9/7	9/8	9/9
Switzerland		4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	4/9	
United Kingdom	8	8/1	8/2 HEU	8/3 HEU	8/4 HEU	8/5 HEU	8/6 HEU	8/7 HEU	8/8 HEU	8/9 HEU	
United States	6	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	6/9	

Table 2. National Strategy Statements Submitted in Accordance with INFCIRC/549 [5]

	Strategy Statement	*Strategy Updates*
Belgium	Add. 3(3/98)	3/2 (9/99) 3/3 (10/00) 3/4 (11/02)
China	Add. 7(3/98)	
France	Add. 5a (4/98)	
Germany	Add. 2(3/98)	
Japan	Add. 1(11/98)	
Russia	Add. 9(11/98)	9/1 (3/99) 9/2 (3/00) 9/3 (5/01) 9/4 (9/02)
Switzerland	Add. 4(3/98)	
United Kingdom	Add. 8 (3/98)	
United States	Add. 6(3/98)	6/5 (9/02) 6/9 (6/07)

countries completely declare their holdings in their reports. For example, China has stated that it would not declare plutonium in spent fuel, and reports a zero quantity in its declarations.

As for plutonium strategies, all of the nine states that adhere to the plutonium guidelines have published national strategies, as can be seen in Table 2, above. Belgium, Russia, and the United States have published updates to those strategies. In the Belgian case, updates have included new information in the electricity generation sections and descriptions of new programs and government options in the front and back end of the fuel cycle. Russia's first update added information on the Mayak facility, site of the Fissile Material Storage Facility. Further updates reflected changes in cooperative programs, as well as a potential change in future Russian plutonium holdings after legislation was passed that would allow the import of spent nuclear fuel including plutonium to Russian territory. The United States update in 2002 indicated that it may revise its once-through fuel cycle policy, and its 2007 update included the Global Nuclear Energy Partnership (GNEP) and current status of plans for the Yucca Mountain repository.

It should be noted that the plutonium group did not attempt to develop HEU guidelines because the participants recognized that the nine states involved in the plutonium group were far from the only major state users of HEU, and therefore were not truly representative of all HEU users. However, some states have voluntarily published summaries of their HEU holdings as addendums to their plutonium declarations.

Draft HEU Guidelines

In drafting HEU guidelines, CNS is adopting many of the same elements that exist in the plutonium guidelines, including definitions, transparency requirements, security guidelines, guidelines on transportation and international transfer, and on strategies for material management. The military threat posed by HEU—use in a nuclear explosive device—is similar to the threat posed by plutonium (although a simple, gun-type nuclear device can only be made using HEU, thus making this material an even greater threat than plutonium). However, since the uses of HEU and quantities of the material are vastly different from plutonium, we have necessarily had to alter many of the details in the plutonium guidelines. Indeed, there remain questions in several areas of our draft. We hope to finalize our proposed language through discussions with technical experts and specialists in nuclear policy in the upcoming months.

<u>Definitions</u>

While the plutonium declarations include unseparated material (in spent fuel), they do not otherwise cover irradiated material. The HEU guidelines, on the other hand, must refer to all uranium enriched over 20%, whether irradiated or not, in fuel, targets for medical isotope production, or other materials. One reason for the importance of including irradiated material is that this material loses its "self-protecting" quality over time. Furthermore, some materials (such as those used in critical assemblies) are only lightly irradiated in the first place, and continue to have very high enrichment levels after they are spent. Finally, it is also a relatively simple process to extract the U-235 from most spent fuel.

A recent study of spent HEU targets used in Mo-99 production illustrates the risks. The U-235 content in the irradiated targets is typically still above 90%, due to their relatively low burn up, while the spent target material can be contact handled after a fairly short period of time due to the minimal amount of long-lived fission products in this material: after three years of storage, the dose a terrorist would receive from handling the material would be just 13-37 mrem/hour per gram (depending on the processing), while 5-8 million mrem are required to cause immediate disorientation.[6] To reiterate, the conclusion of scientists at Argonne National Laboratory is that "converting [irradiated target material] to a weapon would not require elaborate shielding and could be performed in a garage with minimal dose to the processors."[7] While spent nuclear fuel assemblies from research reactors may have far higher levels of long-fission products upon their discharge from a reactor, over time they cool, and can similarly be handled with minimal shielding.

Thus, all types of materials containing highly enriched uranium must be included to make management guidelines effective. However, some threshold quantity should probably be specified for inclusion in declarations. This quantity should likely be on the order of several grams.

MC&A and Transparency

Like plutonium, HEU should be subject to an effective national material control and accounting (MC&A) system, based on material balance areas, with physical and book inventories and regular verification of these inventories. In order to increase public understanding of HEU management, aggregate statements of HEU inventories should be published on an annual basis, similar to those currently provided by some countries together with their plutonium declarations (indeed, these declarations could easily be made in tandem). The declarations should take a standard form, so that national governments and facility operators understand exactly what categories of information to report and by what measurements. Further, a national regulatory agency should be made responsible for gathering this information before its submission to the IAEA for publication, in order to ensure that the data is as accurate as possible. This would contrast with the current IAEA Research Reactor Database, which largely relies on the self-reporting of individual facilities, and is woefully out-of-date and inaccurate, thus making it a poor guide to Agency and other programs.

Consideration should also be given to the provision of more detailed statements, relating specific enrichment levels, uses, and possibly security measures as well, to the IAEA in order to facilitate planning at an international level and help the Agency identify facilities in need of assistance.

Physical Protection

Given the likelihood that the use of HEU will continue for quite a few years, even if programs to minimize its use were to expand, it is important to develop clear guidelines to ensure the security of this material. While reference should be made to the Convention on the Physical Protection of Nuclear Material, until the July 2005 amendments to the convention enter into force—which could take some time—it only covers materials in international transit, and not materials in domestic use.[8] The July 2005 agreed text, moreover, does not recommend specific levels of

protection for particular types and amounts of fissile material, but instead simply recommends that states base physical protection on "the state's current evaluation of the threat." United Nations Security Council Resolution 1540, similarly, requires states to "develop and maintain appropriate effective physical protection measures."[9] While an important requirement, particularly since it is both mandatory and comes with the requirement that states report what they are doing to meet this requirement, it does not specify any minimum standards for handling fissile materials, including HEU.

Therefore, like the plutonium guidelines, an annex will be required in the HEU guidelines that specifies minimum levels of recommended physical protection for various types and quantities of uranium and levels of enrichment, detailing both administrative and technical measures. The categorization of HEU types should follow the basic categories in INFCIRC/225, on the physical protection of nuclear material, which defines Category 1 material as 5 kg or more, Category 2 as 1-5 kg, and Category 3 materials as 15 g-1 kg. It should be noted that INFCIRC/225 includes irradiated material that has a radiation level of equal to or less than 1 Gy/hour (100 rad/hour) at one meter unshielded along with unirradiated material in the same category. Additionally, other considerations such as the content of fissile isotopes, recoverability of the material, or other factors might also be included in recommendations for physical security measures. Reference to the most up-to-date version of INFCIRC/225 should be made, as this document should be regularly updated to reflect in the state of the art of state of knowledge about physical protection. To further enhance security, it would be advisable to advocate HEU consolidation and the downblending of HEU stockpiles. Further, the conversion (wherever technically possible) and decommissioning of facilities that are no longer necessary, combined with the prompt removal of fissile materials, should be strongly encouraged.

Transportation

Nuclear materials are commonly regarded as most vulnerable when being transported. At present, requirements for securing HEU transports vary significantly from nation to nation, such that, for example, U.S. HEU exported to Canada for isotope production has a much higher level of physical protection up to the border (required under new, post-9/11 rules, and paid for by the Department of Energy, the exporter) than it does after crossing that border, although it would not appear that vulnerabilities on either side of the border are significantly different. Thus, while national legislation is clearly the basis for transport security within each state, some minimum physical protection levels should be agreed. Further, some of the recommendations of INFCIRC/225 should be reiterated, as adoption of the HEU guidelines would make following them a national commitment (and not simply an IAEA recommendation). These include minimizing the time during which HEU remains in transport, as well as the number of HEU transfers, levels of recommended protection measures for particular categories of material, avoiding the use of regular movement schedules, requiring the predetermination of the trustworthiness of all individuals involved in transport, and limiting advance knowledge of transport information.

International Transfer

Like the plutonium guidelines, HEU guidelines should at a minimum require formal assurances from recipient states that the material will be used for exclusively peaceful purposes, subject to IAEA safeguards, placed under physical protective measures that meet the recommendations of HEU guidelines, and require the consent of the country providing the material before any transfer is made to a third country. Additional requirements that should be considered for inclusion in the HEU guidelines include requiring the use of the material within a specified period of time, return of spent HEU materials to the country of origin or an international storage site (should such a facility be established), as well as a requirement that alternative materials (such as LEU) cannot be used in place of the HEU. An even stronger requirement would be to obligate the recipient country to undertake a commitment to convert the facility destined to use the HEU to LEU as soon as technically and economically feasible.

HEU Management Policies

Recommended management policies must be based on the need to minimize proliferation risks and the risk of theft of the HEU material. The desirability of consolidation and minimization of HEU holdings, and attaining a balance of supply of and demand for HEU materials should be emphasized. In addition, countries should be asked to commit to international cooperation in the development of alternative technologies and the sharing of research and other facilities (the development of international "centers of excellence").

It might be noted that particular attention should be paid to fresh HEU in storage and transport, as well as lightly irradiated materials and spent HEU fuel or targets that have been in storage for a long period of time such that they are no longer "self-protecting." It would be useful if the HEU guidelines could suggest a replacement in national regulations for the "spent fuel standard," which is no longer adequate in the age of potential nuclear terrorism. The new standards should provide specific information on levels of physical protection for various categories of material, possibly at various levels of radioactivity.

Conclusion

As several states have already indicated their interest in the adoption of HEU guidelines, there is a very real possibility that they may be adopted by some states in the near term. The adoption of such voluntary guidelines is an opportunity to help form international norms in this area, and will help programs like RERTR overcome future political challenges. At the current time, there are various states that no longer have the need for HEU use (indeed, some have HEU in storage with no use envisioned in the foreseeable future), but are not willing to transfer or downblend the material as they still view it as valuable and its storage as cost-free, despite the fact that the security of this material is often not at a high enough level and needed security upgrades would be expensive. Expanding pledges to further reduce HEU use or improve the security of this material in the civilian sphere are not likely without a new norm. HEU guidelines are a step in this direction.

CNS has recently initiated a process to promote the adoption of HEU guidelines by states and non-state entities (primarily fuel cycle enterprises), to help ensure the safe and secure management of HEU. This process is beginning with the drafting of suggested guidelines, which are being reviewed by experts in the field and will be discussed at a small meeting of interested parties at the IAEA on September 21. This meeting will also discuss the means for promoting the adoption of the document, once it has been finalized. In order to develop draft guidelines that are as useful and complete as possible, CNS will continue to work with all interested parties after September, and welcomes comments and suggestions on the current draft.

References

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[2] Statement by the Head of the French delegation, First Meeting of the Preparatory Committee for the 2010 NPT Review Conference (Vienna, April 30-May 11, 2007), available on the website of the French Mission to Geneva at http://www.delegfrance-cd-geneve.org/actualite/intervention_dobelle_tnpV_10mai2007_englishversion.htm.

[3] This discussion of the development of plutonium guidelines is based upon statements made by Andreas Friedrich, Head of the Arms Control and Nuclear Affairs Section, Political Directorate, Swiss Department of Foreign Affairs (the former chairman of the consultation group on plutonium) and Jim Finucane, U.S. Department of Energy (who created the plutonium inventory projections at the International Atomic Energy Agency), at the conference "Civil Separated Plutonium Stocks—Planning for the Future," Washington, DC, March 14-15, 2000, http://www.isis-online.org/publications/civil_pu_conference/chap3.pdf.

[4] Table 1 lists submissions, by INFCIRC Addendum number, under the year the report covers. In addition, where a statement of HEU holdings is included, the chart so indicates. Asterix under 2006 French report to indicate that France submitted a report, but the text is missing. Source of statements: http://www.iaea.org/Publications/Documents/Infcircs/1998/infcirc549.pdf; text of state reporting submissions: http://www.iaea.org/Publications/Documents/Infcircs/Numbers/nr501-550.shtml.

[5] Table 2 lists Addendum numbers and dates of INFCIRCs publishing the respective Strategy Statement or Strategy Updates.

[6] George Vandegrift and Edward Fei, "Mo-99 Production Using LEU," presented at the INMM Annual Meeting, Tucson, Arizona, July 2007.

[7] Ibid.

[8] Report by the Director General, “Nuclear Security - Measures to Protect Against Nuclear Terrorism: Amendment to the Convention on the Physical Protection of Nuclear Material,” GOV/INF/2005/10-GC(49)/INF/6, September 6, 2005, http://www.iaea.org/About/Policy/GC/GC49/Documents/gc49inf-6.pdf.

[9] United Nations Security Council, “Resolution 1540 (2004),” S/RES/1540 (2004), April 28, 2004, http://www.un.org/Docs/journal/asp/ws.asp?m=S/Res/1540(2004).