*VIEWPOINT:*

# THE CASE FOR UNIVERSAL FULL-SCOPE SAFEGUARDS ON NUCLEAR MATERIAL

by Annette Schaper[1]

During the next few decades, the international community faces the challenge of dealing with unprecedented amounts of inadequately secured fissile materials. This challenge has emerged as the result of sweeping nuclear arms reductions in Russia and the United States, insufficiently safeguarded civilian and military nuclear installations in the newly independent states (NIS),[2] and the rapid development of the nuclear industry in East Asia. Stockpiles of such material are likely to continue growing, as further Russian-American nuclear reduction agreements (beyond START II) are likely,[3] and both Moscow and Washington are all but certain to declare additional weapons-grade nuclear material excess to their defense requirements.[4] So far, however, many aspects of these activities remain under national control and are not transparent to the international community. All the laudable progress made thus far toward nuclear disarmament, therefore, remains reversible, should the international situation deteriorate.

As a result, the time is now ripe for the development of universal full-scope safeguards to cover not only non-nuclear weapon states (NNWS), as is the case today, but to extend as soon as possible to the nuclear weapon states (NWS) and also ultimately those states that are not party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). The current system imposes safeguards mainly on NNWS that have complied with the NPT for many decades and pose no proliferation danger. Its goal is to detect noncompliance as early as possible. But one lesson of the history of nuclear proliferation is that it is important to detect both the recipient and supplier of sensitive technologies. The NWS themselves are the major source of proliferation relevant materials and technologies. However, under the current global nonproliferation regime, the NWS control these materials only through national legislation, and have no obligation to adhere to international accounting and security standards or to allow inspections of their nuclear materials by any international agency.

New proliferation dangers have increased since the end of the Cold War, creating a situation in which current international safeguards arrangements are inadequate. Huge quantities of weapon materials are becoming excess, and the processes of warhead dismantlement, fissile material transport, storage, and disposition create serious risks of diversion. Though present in all nuclear powers, these risks are especially high in Russia, which is in the process of transforming its nuclear control system. The security of the Russian nuclear production complex is believed to be far below Western standards, and continuing economic difficulties pose the danger of further deterioration; thus, proliferation risks will continue to increase.[5] The international community should make it a priority to develop additional measures to address this situation. Universal international safeguards would promote a security culture and similarly high standards everywhere, thus furthering the goal of nuclear disarmament.

Some processes that lead in this direction have already started. Several bilateral and international collaboration projects are designed to reduce proliferation dangers in Russia and the NIS, notably the Nunn-Lugar Cooperative Threat Reduction (CTR) Program,[6] and other multilateral initiatives aimed at implementing systems of material accountancy,[7] reforming export and border controls,[8] converting military nuclear facilities to civilian purposes,[9] and developing long-term technical solutions for the disposition of fissile materials.[10] In addition to these technical cooperation efforts, political reforms are underway: the trilateral U.S.-Russian-International Atomic Energy Agency (IAEA) talks on IAEA verification of declared excess fissile materials represent a remarkable step toward more international transparency.[11] Substantial reforms of the IAEA's safeguard systems—the "93+2" program—were triggered by the Iraqi proliferation case and are now being implemented. Export control reforms have introduced the principle of full-scope safeguards in the recipient country as a condition

*Dr. Annette Schaper is a Senior Research Associate at the Peace Research Institute Frankfurt (PRIF), Germany.*

for nuclear exports.[12] New transparency measures on plutonium stockpiles, the so-called “Guidelines for the Management of Plutonium” (GMP), have now been negotiated. These steps could provide the basis for even more far-reaching reforms, including an intensified effort to conclude a fissile material cut-off treaty (FMCT).

All these ongoing activities are motivated by a desire to increase the transparency of fissile materials and make the nuclear disarmament process irreversible. The interest of many states in universal safeguards is rising. For example, Germany will participate in disposition projects involving fissile materials only under international safeguards.[13] Among the NWS, however, only the United States has so far put some fissile material declared excess to defense needs under IAEA safeguards. At the Moscow P-8 nuclear safety summit in April 1996, the leaders of the United States, Russia, Germany, Great Britain, France, Italy, Canada, and Japan did agree that IAEA safeguards should be applied to such material *“as soon as practicable.”*[14] This ambiguous rhetoric has not yet been translated into substantive action. If it were vigorously and consistently pursued, however, the objectives outlined in the Moscow summit declaration could mark an historic turn in the traditional structure of the global nonproliferation regime.

This essay argues that the time has come to develop universal international nuclear safeguards. First, it examines the dimensions of the problem, presenting an overview of the current quantities of fissile material and explaining the current status of bans and safeguards on fissile materials, including the IAEA’s “93+2” reforms. Then, it examines the status of the plutonium guidelines and discusses their potential role as a stepping stone toward establishing universal safeguards. It also analyzes the prerequisites for the establishment of universal international safeguards. The next section addresses the special problems caused by dual-use nuclear installations, which are often cited by the NWS as an obstacle to establishing international controls. The essay concludes with a discussion of the specific role that the FMCT could play in fostering the development of a universal safeguards regime.

## THE CURRENT STATUS OF FISSILE MATERIALS

The amount of fissile material needed for one warhead is just a few kilograms. But the total amount of existing military materials is the cumulated production of the last several decades. Thus, the number of warheads that could be fabricated from existing stockpiles is higher than the number of warheads that existed when the nuclear arms race peaked during the Cold War. It is not surprising that the United States and Russia have stopped further production (or intend to do so).[15] However, while existing stocks of fissile material remain outside international controls, the nuclear disarmament process will remain reversible, and any rearmament could easily create similar or higher warhead numbers than those reached during the Cold War.

Existing stockpiles of plutonium and HEU can be divided into the following categories:

1) military direct-use material in operational nuclear weapons and their logistics pipeline;
2) military direct-use material held in reserve for military purposes, in assembled weapons or in other forms;
3) military direct-use material withdrawn from dismantled weapons;
4) military direct-use material considered excess and designated nationally for transfer into civilian use;
5) military direct-use material considered excess and declared internationally for transfer to civilian use without international safeguards;
6) military direct-use material considered excess, declared for transfer into civilian use, and submitted to international safeguards;
7) direct-use material currently in reactors or their logistics pipelines or in storage (naval and research reactors, power reactors, breeders); and
8) irradiated plutonium and HEU in spent fuel from reactors, or in vitrified form for final disposal.

In the NWS and states not party to the NPT, all categories exist at least theoretically, and, in particular, military categories 1 to 5 are not illegal. In the NNWS parties to the NPT, only civilian categories 7 and 8 are allowed. In the NWS, category 6 could already be classified as category 7. Figure 1 gives an overview of plutonium and HEU held by the five declared nuclear powers inside and outside operational nuclear weapons.

Figure 1 demonstrates that large quantities of fissile materials in the NWS are currently neither inside weapons nor declared excess. Such “missing material” falls into categories 2, 3, and 4. It is on the order of hundreds of metric tons, sufficient for tens of thousands of warheads. This material creates a huge gray area, contradicting the aim of irreversible nuclear disarmament. The goal of reducing these large quantities, whose disposi-

*Figure 1: Estimated Inventories of Plutonium and HEU Inside and Outside Operational Nuclear Weapons (in Metric Tons)* [16]

| CATEGORIES | U.S. | FSU | FRANCE | CHINA | U.K. | AVG. TOTAL |
|---|---|---|---|---|---|---|
| ***Inside weapons*** | | | | | | |
| Plutonium | 28 – 37 | ≅ 38 | 1.5 – 2 | ? | ≅1.5 | 75 |
| HEU | 140 – 280 | 165 – 330 | 7.4 – 14.8 | 9.0 – 13.5 | 3 – 6 | 485 |
| ***Unknown disposition*** | | | | | | |
| Plutonium | 10 – 20 | 0 – 76 | 1.5 – 5 | 0 – 6 | 0 – 2 | 77 |
| HEU | 126 – 395 | 0 – 667 | 2 – 23.8 | 1.5 – 16 | 0 – 7 | 553 |
| ***Declared excess*** | | | | | | |
| Plutonium | 38.2 | 50 – 100 [a] | 0 | 0 | 0 | 74 |
| HEU | 174.3 | 500 [b] | 0 | 0 | 0 | 674 |
| ***Under safeguards*** | | | | | | |
| Plutonium | 2 [c] | 0 | 0 | 0 | 0 | 2 |
| HEU | 10 [c] | 0 | 0 | 0 | 0 | 10 |
| ***Total*** | | | | | | |
| Plutonium | 85 ± 2% | 131 ± 25 % | 5.0 ± 30 % | 4.0 ± 50 % | 3.1 ± 20% | 228 |
| HEU | 645 ± 10% | 1025 ± 30% | 24 ± 30% | 20 ± 25% | 8 ±25% | 1722 |

[a] Not an official figure, but an estimate based on working figures used in disposition studies of Russian Plutonium such as the Joint U.S.-Russian Plutonium Disposition Study prepared by the Joint U.S.-Russian Plutonium disposition Steering Committee, September 1996.
[b] Russia has agreed to sell 500 metric tons of weapons-grade HEU to the United States over 20 years.
[c] From Frank von Hippel, "A Program for Deep Cuts and De-Alerting of the Nuclear Arsenals," paper prepared for the 5th ISODARCO-Beijing Seminar on Arms Control, Cheng-Du, China, November 12-15, 1996.

tion is uncertain, has so far been addressed internationally only by the loose pledge to submit it to the recently negotiated GMP "as soon as practicable." The complete abolition of categories 2, 3, 4, and 5 should be a recognized goal of all international efforts to control plutonium and HEU stocks.

## THE CURRENT STATUS OF BANS AND SAFEGUARDS ON MATERIALS

A wide variety of nuclear materials thus exists, which is subject to several international safeguards regimes under varying legal standards. This situation is further complicated by the on-going implementation of the "93+2" reforms, which will take effect in some countries earlier than others. The situation with respect to this material will be clarified politically when the NWS declare substantial quantities of nuclear materials excess to defense requirements. Nuclear disarmament will be made more irreversible when safeguards on this excess material are confirmed by international law.[17] Currently, all NWS (and states not party to the NPT) can move materials between the several categories as they please, with the exception that France and Britain are not allowed unsafeguarded civilian materials (see below). However, France and Britain can transfer civilian materials to unsafeguarded military categories, stripping those restrictions of any real effectiveness.

At present, there are no legal obligations relating to limitations, declarations, or international controls of any kind on the military categories of fissile material, except those contained in national legislation. Some civilian material in the NWS, including U.S. excess military material, is subject to *voluntary* safeguards. But much material is free from any international legal *requirements*. All civilian nuclear material in France and the United Kingdom is subject to EURATOM safeguards. But these countries have the right to withdraw it for defense needs, with the consequence that EURATOM controls cease. If international controls are not tightened, the NWS could become a source of direct-use and dual-use nuclear materials, technologies, and knowledge for potential proliferators.

The NNWS that are parties to the NPT are committed to accept safeguards on all nuclear material used in all peaceful nuclear activities (full-scope safeguards). According to the model agreement with the IAEA, full-scope safeguards are also called INFCIRC/153-type safeguards. The nuclear material of the European Union (EU) members also is subject to EURATOM safeguards, while that of Brazil and Argentina is subject to the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) safeguards (comparable in intrusiveness to those of EURATOM). The group of NNWS may be subdivided into states with good nonproliferation records, which are unlikely to develop nuclear ambitions and those that might be tempted to start a nuclear program (e.g., North Korea, Iraq, or Iran). Countries that in the future might fall into the latter category will in all likelihood be states that will have isolated themselves from the international community. The industrialized NNWS can be a source of dual-use materials, technologies, and knowledge for potential proliferators.

India, Pakistan, and Israel possess of unsafeguarded military and civilian materials. These countries have some civilian facilities that are subject to IAEA INFCIRC/66-type safeguards, but they are restricted only to these facilities and do not cover all materials (also called facility-attached safeguards). Like the NWS, this group of countries could be a source of direct-use and dual-use nuclear materials, technologies, and knowledge usable for nuclear weapons. In sum, there are voluntary, facility-attached, and full-scope IAEA safeguards, and full-scope EURATOM and ABACC safeguards on civil nuclear materials in addition to upgraded IAEA safeguards under the recently-adopted "93+2" measures. Under the definitions issued by the IAEA, nuclear materials can be subdivided into source material and special fissionable material (contains fissile nuclides). Special fissionable material can be further subdivided into direct-use material and other material that first needs enrichment or transmutation to be used for nuclear weapons.[18]

## THE "93+2" SAFEGUARDS REFORM

The latest addition to the international safeguards regime, the IAEA's "93+2" reforms, has already reached the implementation stage. The new safeguards arrangements were adopted on May 15, 1997, by the IAEA and its member states.[19] Each country (or EURATOM, as representative for its members) must still conclude an appropriate agreement with the IAEA implementing these standards. These individual agreement are currently under negotiation. The reforms aim at strengthening the effectiveness and improving the efficiency of IAEA safeguards, and they will set new standards for what is satisfactory verification for the absence of production of fissile materials for weapon purposes. The reforms were a response to Iraq and North Korea's clandestine acquisition activities, which demonstrated that previous nonproliferation tools and efforts were not sufficient.

Traditionally, IAEA safeguards had the primary goal of verifying that declared activities were in compliance with commitments. The "93+2" reforms are designed to enable the IAEA to detect noncompliance: e.g., to uncover undeclared activities at an earlier stage. The reforms anticipate that a country might be both a clandestine seeker of nuclear weapon technologies and a potential supplier of them. The second aspect is an important innovation. The reforms intensify the search for clandestine purchasers by expanding the scope of inspections, allowing inspections of sites with no declared nuclear materials, and permitting the IAEA to take environmental samples. To gather information about potential suppliers, the IAEA has instituted so-called "expanded declarations" that ask for information about activities and equipment functionally related to fuel cycle operations and not only, as before, information on all nuclear material and facilities. These declarations include technologies that constitute important elements in the nuclear fuel cycle infrastructure, such as components of centrifuge enrichment technology. Exports and imports of such technologies also must be declared (as well as ongoing research on them). The agency has established a computerized system to store and retrieve safeguards-relevant information from open sources to assist in interpreting the expanded data and to help build a proliferation or nonproliferation profile of each state. The latter aspect of the reform is remarkable because it indicates a shift in thinking on how to detect proliferation: it focuses on both the recipient and supplier. As a consequence, the reform must apply equally to all potential suppliers, including the NWS. The NWS can be a source not only of dual-use but also of direct-use proliferation relevant technologies.

Accordingly, the principle of universality played a central role during the negotiations. The original proposal did not provide for universality, which provoked strong criticism from NNWS with nuclear industries, notably Germany, Japan, Belgium, Switzerland, and Spain.[20] These countries argued that the reform would be unsuccessful if it were not based on universality and pointed out that their nuclear industries would be hobbled by a competitive disadvantage resulting from discrimination.[21] Extended reporting of technology transfers provides a good example. Analysis of acquisition activities will remain incomplete as long as tracks are lost when goods touch or originate in an NWS. The lack of universality would also result in an injustice: the "good guys" would bear a much heavier burden. Even more than in the NNWS, sensitive goods and knowledge can especially be found in the NWS (e.g., Russia). Without universality, the variations of discrimination would increase: there would be the NWS, the NNWS that have adopted "93+2" safeguards, the NNWS that have not, and states outside the NPT.

In the final draft of spring 1997, substantial concessions were made, especially with respect to intrusiveness and universality. The prospect of having similarly intrusive measures applied on their territories has lessened the demands of several NWS. The NWS have presented unilateral declarations of how to implement the reforms that contain different degrees of acceptance of universality. Those of Russia and China are the least satisfying.[22] The interest in reducing any competitive disadvantage is already largely satisfied by the inclusion of the United States, the United Kingdom, and France in the reform measures. However, nonproliferation would be much better served if Russia and China were also included. An important step towards universality has been taken but it remains to be seen how successfully the reforms will be implemented in the member states (e.g., by specific agreements between the member states and the IAEA, and between EURATOM and the IAEA, respectively). During autumn 1997, the EU members negotiated among themselves a joint position to start negotiations between EURATOM and the IAEA. Again, difficulties arose because of disagreement on the universality of safeguard measures. France and Britain still tried to preserve more privileges for themselves than the others were willing to accept. But, in December, the EU officially declared its readiness for the start of negotiations, which is still faster than the United States, whose start of negotiations with the IAEA is expected in early 1998. In the United States, domestic difficulties are anticipated because of complaints by private industry. The nature of these complaints will in all likelihood be similar to those of German industry.[23]

## THE GUIDELINES FOR THE MANAGEMENT OF PLUTONIUM (GMP)

International negotiations on enhancing the transparency, security, and control of plutonium (known as the International Plutonium Management talks) have been underway since 1992 in Vienna with the goal of formulating GMP. These talks were a response to concerns about the increasing level of worldwide plutonium transfers and the huge amounts of plutonium from dismantled Russian and American nuclear weapons that are not currently subject to international controls. Another catalyst for these discussions was criticism of plutonium shipments to Japan, and a corresponding Japanese initiative to convince other states that its intentions are not military.[24] Japan aims to appease international concerns and secure international tolerance of its civilian plutonium industry by increasing transparency.[25] The participants in the GMP talks were limited to countries with a substantial civilian nuclear industry: the NWS, Japan, Germany, Switzerland, and Belgium, with the IAEA and EURATOM acting as observers. However, the idea was to create a standard set of guidelines that could later be expanded.

At the end of 1992, IAEA Director General Hans Blix took the initiative and invited several states to the International Plutonium Management discussions. The U.N. General Assembly declared itself in favor of an FMCT in September 1993. That same year, U.S. President Clinton described the problem of plutonium disposition as central to the disarmament process, adding that the United States was willing to put excess weapons plutonium under the U.S.-IAEA voluntary Safeguards Agreement.[26] German Foreign Minister Klaus Kinkel also called for an International Plutonium Regime in his 10-

Point Initiative in December 1993.[27] The idea behind this proposal is not simply storage but a more secure way of managing the civilian use of plutonium. Meanwhile, the United States and Japan have taken the lead in transparency by publishing detailed figures of their civil plutonium stocks.[28]

The negotiations were finally concluded in autumn 1997. The resulting guidelines deal with safeguards, radiological protection, physical protection, nuclear material accountancy and control, international transfers, management policies, and transparency.[29] They go beyond existing agreements and include commitments to adapt continuously to the most modern standards and to improve the transparency of stockpiles. Under the guidelines, annual national declarations will provide detailed figures on all kinds of unirradiated civil plutonium. For EU members, these declarations will be completed by EURATOM upon request of the national governments. These guidelines represent a major improvement over current practices, because they will impose similar obligations on both the NWS and the NNWS, in particular requiring that surplus military plutonium be placed under international safeguards. However, the scope and mandatory nature of these commitments were heavily contested; the center of the dispute was the question of whether plutonium should be affected by the guidelines after it has been "designated" or "declared" as no longer required for defense purposes. This wording affects how binding the obligations are. Among the NWS, China in particular finds any obligations concerning its nuclear fuel cycle too intrusive. Germany objected to the reservation "as soon as practicable" (similar to the P-8 summit declaration), and unsuccessfully argued that the NWS should accept a stronger commitment to place military materials declared excess under international safeguards.

The idea of being subject to international controls is still new to the NWS and has to overcome political inertia in order to be accepted. At least France and Britain's civilian fuel cycles are already under EURATOM safeguards, and they have no difficulty accepting the obligations under the proposed GMP. However, to date, they have not declared any plutonium as excess to their defense needs. But the other NWS, being unfamiliar with regular safeguard measures, are still—to different extents—reluctant to commit themselves to IAEA safeguards.

Similar talks on "Guidelines for the Management of Highly Enriched Uranium (HEU)" are likely in the future, as some participants in the GMP talks would like to extend stricter international controls to HEU as well. Negotiations on HEU guidelines, however, will in all likelihood prove even more difficult than the talks on plutonium. Huge quantities of weapons-grade HEU are being used by the NWS as fuel in nuclear submarine reactors, yet they are unwilling to increase transparency with regard to this material. However, in the last few years, new much denser reactor fuels have been invented.[30] They have made it possible to replace HEU fuel with low-enriched uranium (LEU) in almost all civilian research reactors while maintaining the power and volume of the reactor core. This development has resulted in a largely successful conversion campaign for civilian research reactors.[31] It would be worthwhile to investigate the possibility of a similar conversion program for naval reactors.[32]

As a stepping stone toward an effective universal safeguards regime, the GMP are a significant development. The GMP will probably constitute the first international agreement that places control obligations on all NWS. It will affect areas that previously had been under exclusive national control and untouched by international regulations, setting a precedent for future efforts to further extend international safeguards.

## IMPLEMENTING MC & A AND SSACS IN THE NWS

INFCIRC/153-type (full-scope) IAEA safeguards require the establishment and maintenance of a state system of accounting for and control of nuclear material (SSAC), the implementation of which is verified by the IAEA. This system is the result of national legislation, based on technical material control and accountancy measures (MC & A). INFCIRC/66-type (facility-attached) IAEA safeguards do not explicitly call for states to establish a SSAC, but require a "system of records" and a "system of reports" that virtually imply the need for a system similar to an SSAC. In sum, nonproliferation and security of fissile materials and installations are controlled in several steps: the first step is national physical protection measures, the second is technical MC & A measures at the individual facilities, the third is the SSAC run by the state (or, in the case of the EU, by Euratom),[33] and the fourth is additional verification by the IAEA. In the NWS, however, only those facilities placed on "voluntary offer lists" by the NWS must be capable of meeting IAEA safeguards criteria. Only their operators must follow IAEA accounting rules and procedures.

Most nuclear industrial facilities in the United States, Russia, China, and in states that have not signed the NPT have not been designed with international safeguards in mind. As a result, these facilities may lack designs that specifically facilitate an overview of material flows, define strategic points, provide access for taking samples, designate measurement points, contain installations that enable the application of tags and seals, and restrict human entry. Other favorable prerequisites for the installation of control equipment might also be lacking. Before an SSAC can work effectively, an effective system of MC & A must be implemented at individual facilities. Improvements would be necessary for these facilities to meet IAEA standards. They are currently underway at least in Russia, as part of various international collaborative projects for the improvement of nuclear security, separate from discussions of a fissile material production cut-off. Completing these improvements is a challenge, but not an insurmountable obstacle.[34] A similar, though smaller, effort was necessary for the implementation of full-scope safeguards in South Africa.

Likewise, SSACs compatible with IAEA standards are still lacking in some countries (e.g., Russia).[35] While in the United States, France, and Britain the SSACs are based on principles compatible with IAEA standards, this is not yet the case in Russia, and probably not yet in China either or the states outside the NPT. Russia is currently reforming its system. In the Soviet era, the key element was control over personnel, not over nuclear material itself. The tradition of extreme secrecy concerning the nuclear military complex has resulted in part from the intensive monitoring of personnel. Each Russian facility had deadlines for reporting, but reports were based on bookkeeping practices and individual accountability, not on physical measurements. In November 1995, a new "Law on the Use of Atomic Energy" entered into force in Russia. This law introduced the internationally recognized principle of measured material balance as the basic concept of the Russian SSAC, but its full implementation will take time. Among the many steps that must still be taken to bring the Russian SSAC into compliance with IAEA standards are: 1) implementing regulations containing technical, organizational, and reporting requirements for MC & A; 2) determining the relationship between the MC & A measures in an individual facility and the national SSAC; 3) installing measurement systems at facilities; 4) preparing initial physical inventories; 5) training personnel to work under the new system, and; 6) making the transition from the old to the new system.

It is not yet clear which Russian agency will be responsible for which kind of controls and regulations.[36] Current plans indicate that the Ministry of Atomic Energy (Minatom) will assume responsibility for the MC & A of nuclear materials intended for civil and defense purposes. The Ministry of Defense will implement MC & A measures regarding nuclear materials used for defense purposes. Gosatomnadzor will be charged with the oversight of nuclear materials intended for peaceful purposes. The State Customs Committee will control the transport of nuclear materials across Russian borders. Overlapping responsibilities and rivalries among these agencies have caused problems that must be solved before the new SSAC can be complete. Collaboration with the IAEA can start long before this process is finished, however, and the preparations and installation of safeguards can take place in parallel. In most other NWS and states not party to the NPT, different authorities are responsible for the control of the military and civilian nuclear cycles. These states might anticipate problems in the transition of material and facilities from military to civilian use. It would be beneficial for these states to discuss their experiences and begin collaborative work on solving related problems.

Because of these difficulties, a certain time lag between the acceptance by the NWS of international safeguards and their actual implementation should be expected. However, the necessary time frame should be specified in any relevant international agreements. Treaty language like the rather vague phrase "as soon as practicable" could delay success indefinitely. It would be more advisable to negotiate a protocol containing timetables for specific steps, perhaps combined with technical collaboration programs between individual states, the IAEA, EURATOM, or other SSAC agencies.

## DEALING WITH DUAL-USE AND MILITARY FACILITIES

The major argument that the NWS cite against international safeguards and a highly intrusive verification regime is the problem of dual-use facilities. In such facilities, the NWS argue, verification activities might result in the release of sensitive information. Such facilities could be former military production sites, maintenance facilities still in use, or dismantlement facilities for nuclear warheads. Maintenance facilities repair and refabricate aging warheads, engage in other stockpile stewardship activities, and remove tritium from aging warheads. While the NWS are unlikely to object to verification measures in closed facilities, they would be unlikely to accept such measures in maintenance and dismantlement facilities. The threshold states outside the NPT probably have facilities that would pose similar problems. Verification activities might reveal the following types of sensitive information.

• **The isotopic composition of nuclear materials:** Russia, in particular, is reluctant to reveal the exact isotopic composition of its weapons HEU or plutonium. Moscow still regards this data as highly classified.[37] It is possible that inspections and measurements conducted at former military sites might find traces of weapons materials, even if they had been removed prior to the start of inspections. In the several international studies on the disposition of Russian weapons plutonium, notional numbers for isotopic composition taken from the American arms control literature were used in the absence of genuine data. Under the U.S.-Russian HEU deal, only diluted uranium is transferred to the United States, so that the original isotopic composition of the blended-down HEU remains unknown. However, from the point of view of proliferation danger, there is no clear reason to conceal this information. It is already generally known that NWS prefer a high Plutonium-239 content for weapons plutonium and a high Uranium-235 content for weapons-grade uranium. Possible Russian motivations for maintaining secrecy on this issue include bureaucratic inertia, and the fear that embarrassing surprises could be revealed. Isotopic concentration data might reveal, for instance, that Russian weapons-grade material is of embarrassingly low quality, or conversely that the plutonium has been further enriched.[38]

• **The amount of material needed for one warhead:** Another possible problem with inspections at former military sites is that scraps or tools there might reveal the size of nuclear weapons pits. The pit is the fissile part of a nuclear warhead, and in modern devices, it is always shaped as a hollow sphere. The exact size and dimensions of pits are classified in all NWS, and there are presumably wide variations. Although the revelation of this data would not pose a major proliferation risk, some important conclusions could be inferred from it. Knowing the dimensions of existing pits would allow states or others seeking to build nuclear weapons to estimate how much material was in the pit. The dimensions of the pit, if combined with data on the yield of the warhead, also could make possible estimates of the factor by which the pit would need to be compressed, an important element in designing an implosion-type nuclear weapon. Even after the Cold War, the NWS regard the release of such data as unacceptable. In order to prepare such former military facilities for international safeguards, the removal or destruction of such scraps and tools is absolutely necessary. This work is urgent anyway in order to minimize proliferation dangers.

• **Design information for warheads**: When a fissile material production facility or storage site is collocated with a warhead factory, machinery used for pit fabrication and conventional explosive ignition technology could be located at the site. Such collocation is believed to be an issue at some Russian facilities. The information revealed by access to this type of equipment presents a real proliferation threat and must be protected accordingly. In order to prepare for future inspections, it is imperative for states with such collocated facilities to separate physically existing fissile material production/storage sites (at least those intended for future civilian material) from weapons manufacturing installations. If such facilities are in close proximity, special arrangements will be necessary to protect the sensitive areas. Like the interior of any weapon dismantling facilities, shipments to and from military-related buildings at such dual-use sites must be exempted from inspections. The absence of illegal enrichment or reprocessing operations could be verified with a certain level of confidence by external environmental monitoring of effluents. The first task when safeguards are initiated is to examine the design of a facility. Close integration of different activities might pose initial problems, but a timetable can be implemented for the separation to be completed.

The high degree of civilian-military integration at several Russian HEU production facilities illustrates the problems discussed above. The Ural Electrochemistry Plant, for example, located in Verkh-Neyvinsk, would almost certainly present dual-use problems because it has facilities related to the storage and manufacturing of HEU weapons components at the same site as civilian enrichment facilities. Similar problems are likely to emerge at the Siberian Chemical Combine (Tomsk-7), the Electrochemistry Plant (Krasnoyarsk-26), and the Electrolyzing Chemical Combine (Angarsk), where military and civilian enrichment facilities are collocated.[39] As all these plants are former military production sites. They would be subject to inspections under any future FMCT, in addition to being monitored under any universal safeguards agreements. Problems with such collocation in France and Britain do not exist because of EURATOM safeguards; but maintenance, the removal of Americium, or future dismantling activities could raise similar issues for Paris and London as well.

Another similar example of dual-use problems in a NNWS is the military HEU and other uranium from the former Soviet military complex that is currently located in Kazakstan.[40] Kazakstan, in an effort to implement full-scope IAEA safeguards, submitted information on this material to the IAEA. Russia, however, has protested against the implementation of IAEA safeguards with regard to this material because it considers the information too sensitive. Similar problems have arisen at the former Soviet nuclear test site in Semipalatinsk, Kazakstan. Here again, Kazakstan as a NNWS has legal obligations that are contradictory to Russian interests as a NWS. Before international safeguards can be implemented, these problems must be resolved.

To safeguard nuclear material capable of revealing classified information, IAEA material accounting procedures could be replaced with initial transparency measures. These measures would combine item accounting and qualitative measurements to confirm the emission characteristics of the declared nuclear material while avoiding the disclosure of sensitive data. Thus, sealed containers holding excess declared weapons material could be monitored remotely to ensure that they are not returned to weapons use. For instance, classification guidelines in the United States allow measurement at a fixed distance of the total radiation emitted from a weapons component container. Nevertheless, to facilitate the establishment of a universal safeguards regime, NWS should relax their classification laws.[41]

## CONCLUSION: TOWARD AN FMCT AND A UNIVERSAL VERIFICATION SYSTEM

Several political and technical hurdles remain to be overcome before universal full-scope safeguards can be attained. Paving the way for acceptance of universal safeguards by the NWS and threshold states is a political problem that requires time to resolve. Implementing appropriate material accountancy systems in these countries is a technical problem that requires financial resources and time. Furthermore, implementing the safeguards themselves poses additional technical challenges that require more time and money. Currently, international safeguards in the NNWS are based on INFCIRC/153 and the "93+2" reforms. The costs of a universal system based on these standards would be about three times the current costs.[42] However, this would total only about $140 million annually, a bargain in terms of proliferation effectiveness. Compare this sum, for example, with the $1.5 billion the United States allocated for the maintenance of the Nevada test site in 1996. Aside from the financial costs, the organizational efforts of the IAEA would also have to triple; the number of inspectors will be much larger, requiring further reforms in the IAEA. One of the frequently voiced objections against a universal safeguards system is that the organizational problems involved will be insurmountable owing to the complicated, existing procedures of appointing IAEA inspectors.

Reform of the present safeguards system is thus necessary if it is to be expanded. Excessive costs, a bloated bureaucracy, overly complicated formal procedures, duplication, low effectiveness, and too many inspections in places where confidence is high anyway, were already among the criticisms of the IAEA that prompted the "93+2" reforms. Further reforms aimed at improving efficiency are necessary if universality is to become a realistic prospect. Several steps will be necessary, among them further strides toward reducing the traditional focus on the receiving party in nuclear transactions and increasing scrutiny on supplier countries, a process that started with "93+2" reforms.

An FMCT could serve as a driving force to help institutionalize the principles of transparency, irreversibility, and universality. The negotiation of a FMCT would place fissile material control reforms in the arms control context. The major benefit would be reinforcement of all other efforts, and the general strengthening of the nonproliferation regime. The FMCT would ensure that verification measures are developed and applied in the NWS. The scope of the cut-off will define a legal framework for the future, which, as a minimum requirement, must ensure that the total amount of military direct-use materials can only be reduced. The treaty would be an even stronger nonproliferation instrument if it ensured that categories 3 (military material withdrawn from dismantled weapons) and 4 (military material declared excess to defense needs) are abolished and category 2 (military material held in reserve) is substantially reduced. In addition, it would be preferable if the treaty required that the quantity of material in category 1 (military material in operational weapons) be declared, which would be a variant of the German proposal for a nuclear weapons register under U.N. auspices.[43]

At the moment, the Conference on Disarmament, which is the most appropriate forum for negotiating an FMCT, is deadlocked. The content, scope, and verification mechanisms of any potential cut-off treaty thus seem unclear. The reasons for the stalemate can be found mainly in the experience of the CTBT negotiations.[44] But, if the deadlock persists, suspicion might grow among many states that good will on the part of the NWS and the threshold states is lacking. However, a cut-off treaty would be an integral part of a new concept, and it would be a great mistake to abandon the idea.

Indeed, the time is ripe for the introduction of regulatory measures also in the NWS and for the creation of a fundamentally new concept of how to deal with fissile materials.[45] The following principles should be used as a base for new regulations and agreements: *transparency* of fissile materials, in contrast to the former secrecy in the NWS during the Cold War; *irreversibility* of transfers of fissile materials from the military into the civilian use; and *universality* of international measures.[46] It is now widely understood that nuclear activities are not only national concerns but are of legitimate interest to the international community. However, while transparency is accepted and practiced in the NNWS, it is still new to the NWS and the states outside the NPT. The degree to which the NWS are ready to endorse IAEA safeguards for themselves varies. While the United States shows an increasing openness, Russia has yet to consider transparency seriously. V. N. Misharin, a former Soviet diplomat who served two tours of duty at the IAEA stated in an interview on safeguards: "The IAEA...should keep in mind that large segments of Russia's nuclear industry will remain outside [of] IAEA control."[47] Ambassador Sha Zhukang presented China's position on verification of a cut-off treaty as: "The verification measures should be [the] least intrusive in nature and sufficient care be taken to avoid abuse."[48] Despite these obstacles, the international community should urge the NWS to accept international safeguards over their fissile materials as a crucial step toward reducing proliferation risks and making nuclear disarmament irreversible.

Over the long term, distinctions between the civilian nuclear complexes of the NWS and the NNWS cannot be maintained.[49] A future universal system must be different than the current system, characterized by a new safeguards culture, and based more on technical and political judgment than on the schematic implementation of quantification measures. Reforms will have to address several criteria: finances, organization, decisionmaking, effectiveness, concern about noncompliance, and standards (such as significant quantities). However, many of these reforms will become necessary anyway because of various nonproliferation and disarmament problems that demand new solutions. Seen from this perspective, a new global approach could potentially lay the basis for a future nuclear-weapon-free world. As William Walker has argued, "the regulatory situation in all countries, including the NWS, should be approached *as if the world is preparing for total nuclear disarmament*, whether or not that is a desirable or realistic prospect."[50]

---

[1] The work for this paper has benefited greatly from discussions with Harald Müller, William Walker, PRIF's nonproliferation group, and members of the German Foreign Office. Scott Parrish and two anonymous reviewers have made very useful suggestions and have taken great care in the editing process. The author wishes to thank them all. The opinions of this paper are those of the author and not necessarily those of the German government. Parts of this paper are derived from a larger study, Annette Schaper, *A Treaty on the Cutoff of Fissile Material for Nuclear Weapons – What to Cover? How to Verify?* PRIF Reports, No. 48, July 1997.

[2] Oleg Bukharin, "Upgrading Security at Nuclear Power Plants in the Newly Independent States," *The Nonproliferation Review* 4 (Winter 1997), p. 28; for an overview on the security of the Russian nuclear complex see: Oleg Bukharin, "Security of Fissile Materials in Russia," *Annual Review of Energy and Environment* 21 (1996), pp. 467-496.

[3] R. Jeffrey Smith, "More Nuclear Disarmament Beyond START II is Expected," *The Washington Post*, January 23, 1997, p. A4.

[4] For a detailed study of the problem of excess plutonium and its disposition see, National Academy of Sciences (NAS), Committee on International Security and Arms Control (CISAC), *Management and Disposition of Excess Weapons Plutonium* (Washington, D.C.: National Academy of Sciences, 1994); NAS, CISAC, *Management and Disposition of Excess Weapons Plutonium: Reactor Related Options* (Washington, D.C.: National Academy of Sciences, 1995).

[5] William Potter, "Before the Deluge? Assessing the Threat Of Nuclear Leakage From the Post-Soviet States," *Arms Control Today* 25 (October 1995), pp. 9-16; Annette Schaper, "Nuclear Smuggling in Europe – Real Dangers and Enigmatic Deceptions," paper presented at the forum on Illegal Nuclear Traffic: Risks, Safeguards and Countermeasures, Como, Villa Olmo, spon-

sored by the EU Joint Research Center, June 11-13, 1997, proceedings (forthcoming); Vladimir A. Orlov, "Accounting, Control, and Physical Protection of Fissile Materials and Nuclear Weapons in The Russian Federation: Current Situation and Main Concerns," paper presented at the International Seminar on MPC & A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997.

[6] Department of Defense, *1997 Annual Defense Report*, Chapter 7: "Cooperative Threat Reduction" (Washington, D.C.: U.S. Government Printing Office, 1997); U.S. General Accounting Office (GAO), *Weapons of Mass Destruction: Status of the Cooperative Threat Reduction Program* (Letter Report, GAO/NSIAD-96-222, 09/27/96). For assessments see: Jessica E. Stern, "U.S. Assistance Programs for Improving MPC & A in the Former Soviet Union," *The Nonproliferation Review* 3 (Winter 1996), p. 17; and Oleg Bukharin, "U.S. Cooperation in the Area of Nuclear Safeguards," *The Nonproliferation Review* 2 (Fall 1994), p. 30.

[7] Aleksander Rumyantsev, "The Accounting and Control of Nuclear Material and Radioactive Substances in Russia," *Yaderny Kontrol English Digest* 1 (Spring 1996), pp. 5-8.

[8] Elina Kirichenko, "Evolution of the Russian Nonproliferation Export Controls," *The Monitor* 2 (Summer 1996), p. 8.

[9] For this purpose, the International Science and Technology Center has been created with the objective of funding civilian projects with international collaboration involving scientists from the Russian nuclear weapons complex. See: The International Science and Technology Center (ISTC), *January – December 1995 – Second Annual Report*, (Moscow: ISTC, 1996); for the activities of the IAEA see: Sven Thorstensen, "Nuclear Material Accounting and Control: Coordinating Assistance to Newly Independent States – An Overview of IAEA-Supported Activities to Help Former Soviet Republics Establish State Systems Of Accounting and Control," *IAEA Bulletin* (January 1995), p. 29; for the activities of the Europeans see: European Commission, *Communication from the Commission to the Parliament and the Council. Illicit Trafficking in Nuclear Materials and Radioactive Substances – Implementation of the guidelines laid down in the communication from the Commission of 7 September 1994*, (COM(94)383) *and in the Conclusions of the Essen European Council*, COM (96) 171 (Brussels, 19 April 1996); and Commission of the European Communities, DG XVII, *EURATOM-Russian Cooperation in Nuclear Materials Accountancy and Control* (Luxembourg, March 31, 1997); see also, Todd Perry, "Stemming Russia's Plutonium Tide: Cooperative Efforts to Convert Military Reactors," *The Nonproliferation Review* 4 (Winter 1997), p. 104.

[10] The disposition efforts are still in their infancy. The still most advanced disposition project is the proposed French-German-Russian cooperation on the fabrication of MOX from disarmament material whose technical feasibility has been demonstrated by several studies and whose acceptance has been endorsed by a meeting of the P-8 Nonproliferation Experts Group in November 1996. See Ann MacLachlan, "French, Germans and Russians aim for 1998 decision on MOX plant," *Nuclear Fuel*, December 2, 1996; National Academy of Science and German-American Academic Council (GAAC), *U.S.-German Cooperation in the Elimination of Excess Weapons Plutonium*, (Washington, D.C.: National Academy of Sciences, July 1995). The idea of making use of the abandoned German MOX facility at Hanau which would have secured maximum transparency was not pursued because of lacking public acceptance. See: Annette Schaper, "Using Existing European MOX Fabrication Plants for the Disposal of Plutonium from Dismantled Warheads," in: William G. Sutcliffe, ed., *Selected Papers from Global '95*, (UCRL-ID-124105, Livermore: Lawrence Livermore National Laboratory, June 1996), p. 197.

[11] Department of Energy, *Trilateral Initiative on Verifying Excess Weapon Origin Fissile Materials*, (Press Statement, November 8, 1996); Bruno Pellaud, "International Verification of US and Russian Materials Released for Storage and Disposition," paper presented at the International Policy Forum: Management & Disposition of Nuclear Weapons Materials, Landsdowne, Virginia, February 12, 1997.

[12] Harald Müller, ed., *Nuclear Export Controls in Europe* (Brussels: European Interuniversity Press, 1995).

[13] National Academy of Sciences and German-American Academic Council (GAAC), *U.S.-German Cooperation in the Elimination of Excess Weapons Plutonium*.

[14] Moscow Nuclear Safety and Security Summit Declaration, April 20, 1996.

[15] At the time being, production of military plutonium in Russia still takes place because the production reactors simultaneously produce energy and the spent fuels must be reprocessed for technical reasons. See Perry, "Stemming Russia's Plutonium Tide."

[16] Numbers for totals, inside weapons, and U.S. declared excess derived from David Albright, Frans Berkout and William Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities and Policies* (Oxford: Oxford University Press, 1997).

[17] This is primarily a political irreversibility. One hundred percent technical irreversibility is not possible; but it can be approached by some disposition methods.

[18] See *IAEA Safeguards Glossary* (Vienna: International Atomic Energy Agency, 1987).

[19] IAEA Committee on Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System, *Model Protocol Additional to Existing Safeguards Agreements Between States and the International Atomic Energy Agency*, May 15, 1997. IAEA, "IAEA Board of Governors Approves Strengthened Measures to Verify Nuclear Weapons Pact" (Press release PR 97/9, May 16, 1997); the proposals made by the IAEA are described in: Suzanna van Moyland, *Verification Matters: The IAEA's Programme '93+2'*, VERTIC Report 10 (January 1997). For a short description of problems during its negotiations see: Annette Schaper, "Detection of Non-Declared Activities Towards Nuclear Nonproliferation," *Proceedings of the Workshop on Science and Modern Technology for Safeguards in Arona (Italy), 28-31 October, 1996* (Ispra, 1997), p. 341.

[20] "Statement by the Utilities Employing Nuclear Energy and the Nuclear Industry in Germany on the IAEA Programme 93+2," press statement, June 3, 1996.

[21] Among the disputed problems were: the conformity of the reforms with domestic law, especially where access to private property was concerned; implications for the verification agreements between the IAEA, EURATOM, and the NNWS members of the EU; the protection of industrial secrets, and the lack of specific managed access provisions similar to those in the Chemical Weapons Convention.

[22] French declaration: *Measures that France Intends to Apply for the Implementation of the 93+2 Programme*, May 13, 1997 (unofficial English translation from French); British declaration: *Implementation in the UK of Measures Provided for in the Programme 93+2 Model Protocol*, May 13, 1997; Chinese declaration: *Statement by China on its Contribution to the Implementation of "Programme 93+2"*, May 15, 1997 (translation from Chinese); Russian declaration: *Statement by the Delegation of the Russian Federation at the Special Session of the IAEA Board of Governors*, May 15, 1997 (unofficial translation from Russian).

[23] "Statement by the Utilities Employing Nuclear Energy and the Nuclear Industry in Germany"; Representatives of the German nuclear industry, interview with the author, December 1997.

[24] Naoaki Usui, "Oyama says Japan will discuss International Plutonium Management," *Nucleonics Week*, March 4, 1993.

[25] Shinichiro Izumi, "International Management of Plutonium," *Plutonium* 12 (Winter 1996), p. 3.

[26] Fred McGoldrick, "US Fissile Material Initiatives," *Proceedings of the Symposium on International Nuclear Safeguards*, Vienna, March 14-18, 1994, p. 17.

[27] German Foreign Minister Klaus Kinkel, "German 10-Point Initiative for Nuclear Nonproliferation," Declaration, Bonn, 15 December 1993, Summary in: *Nuclear Proliferation News* 5, June 10, 1994.

[28] Naoaki Usui, "Western Countries Will Make Plutonium Inventories Public," *Nucleonics Week*, January 26, 1995. The U.S. figures have been published by: Department of Energy, "Plutonium: The First 50 Years. United States Plutonium Production, Acquisition, and Utilization from 1944 to 1994" (Washington, D.C.: U.S. Government Printing Office, February 1996). The Japanese figures are published annually since 1995: "Info-clip: Plutonium Inventories in Japan," *Plutonium* 11 (Autumn 1995), p. 15. EU members do not necessarily have national nuclear material accountancy, this authority has been transferred to EURATOM. EURATOM does not make legal dis-

tinctions between transfers within the territory of one member state and transfers that cross inner EU borders. However, the GPM explicitly speak of "Governments" and "national figures." But it also contains the reservation that EU members "will implement this guideline in the light of its legal obligations under the EURATOM Treaty."

[29] In agreement with already existing legal obligations, such as the EURATOM Treaty, safeguards agreements with the IAEA, the International Convention on Nuclear Safety, and others.

[30] IAEA, *Research Reactor Core Conversion Guidebooks* (IAEA-TECDOC-643, April 1992), Vols. 1-5.

[31] In this area, the U.S. RERTR program has spent about $50 million, and the German AF-Program DM 51.1 million. An exception are new reactors that make already use of the new results: e.g., that use the denser fuel but *not* with LEU but *again* with HEU. The only one would be the newly planned new research reactor FRM-II at Garching. See Annette Schaper, "Der geplante Forschungsreaktor in Garching – Rückfall in alte Sünderzeiten deutscher Nichtverbreitungspolitik?" *HSFK-Standpunkte* 3 (March 1996); Hans-Jürgen Didier and Richard Bätz, "Die Garchinger Hochflußneutronenquelle ist im Bau," *Atomwirtschaft* 42 (March 1997), p. 166.

[32] A naval reactor core conversion program would be also a most convincing argument in favor for phasing out the civilian use of HEU altogether, including the planned German reactor in Garching. As a consequence, a ban on *all* HEU production could become a realistic prospect.

[33] Often the terms SSAC and MC & A are used synonymously. The precise meanings are: the SSAC is a legal body and an instrument that defines the technical and practical MC & A measures.

[34] The IAEA views itself as well prepared for this task. See Svein Thorstensen, "Fissile Material and Verification – IAEA Capability and Infrastructure for Verification of Fissile Material," Presentation at the Cut-Off Convention Workshop, Toronto, Canada, January 17-18, 1995.

[35] Source of this paragraph: Alexander N. Rumyantsev, "Establishing a SSAC in Russia: structural, organizational, budgetary and political problems," paper presented at the International Seminar on MPC&A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997.

[36] Yuriy Volodin, "Russian Efforts to Improve Regulation and Maintenance of the Account, Control and Safeguards of Nuclear Materials at Nuclear Installations," paper presented at the International Seminar on MPC&A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997. Volodin is a Gosatomnadzor official. In this paper, the SSAC is called *State MC & A system*.

[37] In the United States, the isotopic composition of fissile materials is classified as long as the material is in warhead component form. As soon as this form is modified, the masses and isotopic composition can be revealed. See J.T. Markin, W.D. Stanbro, "Policy and Technical Issues for International Safeguards in Nuclear Weapon States," in *International Nuclear Safeguards 1994* (Proceedings of a Symposium, Vienna, March 14-18, 1994, Vol. II), p. 639. In Russia in contrast, the isotopic composition of disarmed materials remains classified.

[38] Indications in this direction can be seen in the Tengen smuggling case: In 1994, a smuggled sample of plutonium from Russia was detected in Tengen (Germany) that originated in Russia and apparently has been enriched in Plutonium-239 with centrifuges. Since Russian warheads are said to be constructed in a way that does not take into account later dismantling, it might be assumed that some Russian warheads consist of enriched plutonium. See Schaper, "Nuclear Smuggling in Europe – Real Dangers and Enigmatic Deceptions."

[39] Oleg Bukharin, "Integration of the Military and Civilian Nuclear Fuel Cycles in Russia," *Science & Global Security* 4 (1994), p. 385.

[40] Gennadiy Pshakin, "Methods to Cope With Material Protection Problems in Russia and the CIS: How to Draw a Line Between Civilian and Military Sector," paper presented at the International Seminar on MPC&A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997.

[41] J.T. Markin *et al*., "Policy and Technical Issues for International Safeguards in Nuclear Weapon States."

[42] IAEA, "A Cut-Off Treaty and Associated Costs – An IAEA Secretariat Working Paper on Different Alternatives for the Verification of a Fissile Material Production Cut-Off Treaty and Preliminary Cost Estimates Required for the Verification of these Alternatives," paper presented at the Workshop on a Cut-Off Treaty, Toronto, Canada, January 17-18, 1995. Fred McGoldrick (U.S. Department of State) stated in 1994: "Some argue that the benefits of safeguards in nuclear weapon States are not commensurate with the costs. I think they are, and many share this view." See Fred McGoldrick, "U.S. Fissile Material Initiatives – Implications for the IAEA," *Proceedings of the Symposium on International Nuclear Safeguards, Vol. I.* (Vienna: International Atomic Energy Agency, March 14-18, 1994), pp. 17f, 20.

[43] Kinkel, "German 10-Point Initiative for Nuclear Nonproliferation." For the significance of this proposal and the reaction of the NWS see: Harald Müller, "Transparency in Nuclear Arms: Toward a Nuclear Weapon Register," *Arms Control Today* 24 (October 1994), p. 3.

[44] Stefan Keller, "Some Striking Similarities and Some Telling Dissimilarities Between a Cutoff Convention and a CTBT," contained in the appendix to Schaper, *A Treaty on the Cutoff of Fissile Material for Nuclear Weapons*.

[45] Albright *et al.*, *Plutonium and Highly Enriched Uranium*, especially Chapter 15.

[46] William Walker, "Reflections on Nuclear Transparency and Irreversibility: The Re-Regulation of Partially Disarmed States," Background paper for the Conference on the Fissile Material Cutoff sponsored by the Brookhaven National Laboratory, Science Applications International Corporation, and the Peace Research Institute Frankfurt, Schlangenbad, Germany, July 25-27, 1997.

[47] Vladislav N. Misharin, "IAEA Safeguards in the Former USSR," *The Monitor* 1 (Spring 1995), p. 4.

[48] Ambassador Sha Zhukang, "China's Position on the Cutoff Convention," paper presented at the Workshop on "Fissile Material and Tritium – How to Verify a Comprehensive Production Cutoff and Safeguard all Stocks", sponsored by UNIDIR and INESAP, Geneva, Switzerland, June 29-30, 1995.

[49] Jörg H. Gösele, Hans. Herman Remagen, Gotthard Stein, "A German view on safeguards beyond 1995," in *Proceedings of the Symposium on International Nuclear Safeguards*, Vol. II (Vienna: International Atomic Energy Agency, March 14-18, 1994), p. 701; Hartmut Blankenstein, "Political Considerations on the Future of Safeguards," *Proceedings of the 17th Annual Symposium on Safeguards and Nuclear Material Management*, (Aachen, Germany, 9-11 May 1995), p. 21.

[50] Albright *et al.*, *Plutonium and Highly Enriched Uranium*, p. 456.