A Treaty on the Cutoff of Fissile Material for Nuclear Weapons – What to Cover? How to Verify?

PRIF-Report

Annette Schaper

with an appendix on

Some Striking Similarities and Some Telling Dissimilarities Between a Cutoff Convention and a CTBT

by Stefan Keller

Summary

A treaty to end the production of fissile material for nuclear weapons, the so-called *cutoff,* is one of the most important steps on the disarmament agenda, and all efforts are necessary to overcome the current difficulties in its designated negotiation forum, the Conference on Disarmament (CD). The CD at the time being is deadlocked; the interests, the scope, and the verification of any potential cutoff seem unclear. The complex questions involve political, technical, legal, and economic aspects and constitute a challenge for diplomats and decision makers.

Since 1946, a cutoff has been proposed. In 1993, the topic was placed on the agenda of the CD. The Principles and Objectives for future NPT reviews explicitly list a non-discriminatory and universally applicable Fissile Material Cutoff Treaty (FMCT) as nuclear disarmament measure that must be successfully pursued. The establishment of an Ad Hoc Committee in the CD with a mandate to negotiate a fissile material cutoff treaty struggled with difficulties for more than a year. The central dispute was whether the mandate should refer to existing unsafeguarded stockpiles. The underlying conflict of the CTBT negotiations can be summarized as *nuclear disarmament versus nuclear nonproliferation.* The same conflict is now blocking progress with FMCT negotiations in the CD.

In contrast to the CTBT negotiations, negotiations on an FMCT must take into account several other international activities closely related to its subject. These are security and transparency of fissile materials from nuclear disarmament and of nuclear weapon complexes, international negotiations on enhancing transparency, security, and control on plutonium, under the name of *Guidelines for the Management of Plutonium* (GMP), and the 93+2 safeguards reforms. Whereas the traditional IAEA safeguards had the major goal of verifying compliance with commitments, the 93+2-reforms seek to allow the IAEA to detect noncompliance, e.g. undeclared activities at an earlier stage. All activities show a trend towards safeguards also in nuclear weapon states (NWS). The FMCT would act as policy driver to ensure that verification measures are developed and applied in NWS.

At the center of technical proliferation concerns is *direct use material* that can be used for nuclear warheads without any further enrichment or reprocessing. Those materials are plutonium (Pu) and highly enriched uranium (HEU). A broader category of materials is defined as all those containing any fissile isotopes, it is called *special fissionable materials*. In order to verify that no direct use materials are abused for military purposes, also special fissionable materials must be controlled. An even broader category is simply called *nuclear materials.* The total amount of military materials is the cumulated production of the last decades, and the number of warheads that could be fabricated from it is higher than the nuclear arms race peaked during the Cold War. Pu and HEU can be distinguished into the following categories of utilisation: 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 for transfer into civilian use, 5. military direct use material considered excess and declared for transfer into civilian use, 6. direct use material currently in reactors or their logistics pipelines and storages, and 7. irradiated Pu and HEU in spent fuel from reactors, or in vitrified form for final disposal. Large quantities of materials are neither inside weapons nor declared excess. So far, there are no legal obligations for NWS for limitations, declarations, or international controls of any of the military categories beyond national legislations.

Some variations of a potential FMCT scope with different degrees of obligations are: 1. The *original approach* which bans just future production without measures on existing materials.

This was the original U.S. proposal. It would cement what is already almost reality. 2. The *good-will-approach* which strives for reductions of the amount of military material. It would also ban the transfer of material back to military uses, once it has become civilian, and it would register upper limits that are allowed for undeclared material. 3. The *one-way-approach* which would make sure that the amount of military material is not increased. It would also ban withdrawal of material from international safeguarding and it would implement the obligation to put declared excess material under international safeguards within a defined timetable. 4. The *disarmament approach* which would create mechanisms for reduction. It would oblige the members to adjust the upper limits of undeclared material to future nuclear disarmament treaties, e.g. a START-III treaty and others that might come. 5. The *Indian approach* which would be a time-bound framework for comprehensive nuclear disarmament. This demand is the reason for the current deadlock in the CD.

As there are many variations of scope, also many verification scenarios are possible. Even in case of an FMCT with the most limited scope, the verification must cover not only nonproduction but also nondiversion at least of civilian materials produced later. This is identical to what is already being verified in NNWS under full scope safeguards, with the only exception that NNWS are not allowed the possession of unsafeguarded materials from earlier production. For the NPT, the trust into the NNWS is not high enough to renounce full scope safeguards. Why should NWS be more trusted not to divert fissile materials for nuclear explosive purposes than NNWS? But so far, full scope safeguards are still difficult to accept for NWS.

Safeguards must be designed in a way that they are capable of detecting any of the procurement strategies with a sufficient probability. The specific technological requirements of verification depend on the characteristics of the technical production process. For HEU production, feed material, e.g. natural, depleted or low-enriched uranium, and an *enrichment* facility are necessary. Spent fuel contains plutonium, highly radioactive fission products and their decay products, and unaffected uranium. Plutonium can be separated from spent fuel by chemical means which is called *reprocessing*. The total verification costs of a comprehensive verification system are estimated in the range of 140 million U.S. dollars which is about three times as much as the current annual safeguards expenditure.

Specific verification problems are: 1. naval fuel which often consists of HEU. It must be clarified whether unverified production of HEU for military naval reactors will be banned or not. In case it would be allowed, the FMCT would contain a large loophole which would hardly be acceptable to most negotiating parties. 2. The production of military tritium which is contained in all modern nuclear warheads gives rise to a further difficulty because it might be confused with plutonium production. It would not be convincing to exempt tritium production reactors, although such a demand is likely to be raised in negotiations. 3. Dual-use and military facilities can reveal too much sensitive information. Such facilities could be former military production sites, maintenance facilities still in use, or dismantlement facilities for nuclear warheads. As a start of the verification, materials accounting procedures could be replaced by transparency measures that rely on a combination of item accounting and qualitative measurements. 4. Most plants in the U.S., Russia, China, and in the States outside the NPT have not been planned to take up safeguards. State systems of accountancy and control compatible with IAEA standards are still lacking in some countries. Because of these problems, it must be expected that certain time scales after entry into force will be necessary for the implementation of the verification. However, it is strongly recommendable to specify these times.

Preface

This report would not have been possible without the help of many people. A major input came from a workshop on the topic "The Cutoff-Convention – Interests, Scope, Verification, and Problems" which took place in Bonn on December 12, 1996. It was jointly organized by the Nonproliferation Project of the Peace Research Institute Frankfurt, together with the Arbeitsstelle Friedensforschung Bonn, and the Research Center Jülich. The interesting contributions and discussions during this workshop were very beneficial for this report.

I learned a lot from the collaboration and the numerous discussions with Harald Müller, and I am especially thankful for his critical and constructive comments. Many thanks also to the members of PRIF’s nonproliferation project for helpful discussions. William Walker took great care in thoroughly reading the manuscript, and he contributed numerous helpful comments including many language improvements. I am also grateful to several colleagues from the German Foreign Office and the German CD Delegation for very useful discussions from which I learned much. Hartmut Blankenstein, Matthias Dembinski, Katja Frank, Alexander Kelle, Bernd W. Kubbig, Bernhard Moltmann, and Rudolf Witzel also read parts or the whole manuscript and gave useful comments. However, all errors and all opinions in this report are exclusively my own responsibility.

Many thanks also to Birgit Menigat for her careful and prompt final language editing.

I am especially thankful to Stefan Keller for contributing a chapter on the lessons that can be learned from the CTBT negotiations for future cutoff negotiations (Appendix I: Some striking similarities and some telling dissimilarities between a cutoff convention and a CTBT). Mr. Keller was member of the German CD Delegation and has experienced the CTBT negotiations first hand.

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Annette Schaper

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1 Introduction

Only two years ago, the international arms control community was still confident that a convention to end the production of fissile material for nuclear weapons, the so-called "cutoff", would be next on the negotiation agenda, as soon as the test ban was completed. Meanwhile, the Conference on Disarmament (CD) is deadlocked, and confidence is replaced by stupefaction. Nevertheless, the cutoff is one of the most important steps on the disarmament agenda, and all efforts are necessary to overcome the current difficulties. The Comprehensive Test Ban Treaty (CTBT) can be regarded as a tool to cap the *qualitative* nuclear arms race, e.g. to hinder the future development of qualitatively new nuclear explosives, and a Fissile Material Cutoff Treaty (FMCT) can be seen as its *quantitative* counterpart, capping the amount of material available for new nuclear weapons. Although the proposal of a cutoff was supported by many UN General Assembly resolutions as a prerequisite for nuclear disarmament, it has never obtained the same fame and significance as nuclear disarmament symbol as a CTBT, and it has never played the same prominent role in discussions in international arms control fora such as the NPT review conferences.[1] The reason is not that it is less significant for nuclear disarmament than a test ban, rather there are two quite simple explanations: firstly, it is more closely affected by civilian commercial interests, and secondly, fissile material production is not a spectacular and unambiguous event that can cause headlines and outrage like a nuclear explosion. A cutoff is therefore less famous and more complicated than a test ban, but it is at least as important to nuclear disarmament.

The hope that early negotiations would take place was fueled by the UN General Assembly resolution in December 1993 and by the negotiating mandate adopted by the CD in 1995. In May 1995, the NPT extension conference also agreed upon the Principles and Objectives for Nuclear Non-Proliferation and Disarmament which explicitly identify the cutoff as a disarmament measure that has to be achieved soon. The interests of great powers in a cutoff seemed to converge. Because of nuclear arms reductions, both the U.S. and Russia hold excess nuclear material whose disposition is already a problem. An FMCT would consolidate the status quo which has almost been achieved: UK, Russia[2], and France have all announced that they have ceased production of Pu and highly enriched uranium (HEU) for weapons purposes. China alone has not made a formal commitment, although it too is believed to have ended production.[3] They are likely to see advantages in maintaining the status quo and in preventing an accumulation in other countries.

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[1] This applies particularly on discussions of the realisation of article VI of the NPT which were always related to a CTBT but hardly ever to an FMCT. On analyses of the third and fourth NPT review conferences see H. Müller, D. Fischer, W. Kötter, Nuclear Non-Proliferation and Global Order, SIPRI, Oxford University Press, 1994.

[2] 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.

[3] China has never officially declared a stop, but several officials have made indications, e.g. Jin Huimin of the China Institute of Atomic Energy in a conference paper: "By early 1994, production of fissile materials for weapons may have ended in all the NPT nuclear weapon states." See Jin Huimin, On Verification of the Cut-Off Treaty, Paper for the 5th ISODARCO-Beijing Seminar on Arms Control, 11-16 November, 1996, Cheng-Du, China; China has officially declared its interest to participate in FMCT negotiations.

But now the optimistic mood has faded. The CD has problems agreeing on their working programme for the 1997 session although a general formal agenda has been agreed upon.[4] There is general agreement among most representatives from the 61 CD members on the need to begin negotiations on a cutoff, but a group of non-aligned states, led by India, insists there must also be talks on the phased elimination of nuclear weapons within a time-bound framework, and the group says it will block discussion of other nuclear issues until that demand is met. Already during the CTBT negotiations, India demanded in vain complete nuclear disarmament within a time-bound framework as condition for its adherence. This time, India seems even unwilling to cooperate on the start of any negotiations, in contrast to the start of the CTBT negotiations in 1994.[5] The nuclear weapon states (NWS) are unwilling to agree to any negotiation forum on comprehensive nuclear disarmament. The CD is at a stalemate, and it is uncertain whether, when and how the block will be dissolved.

Another explanation for the current disillusionment concerns the substance of an FMCT which is far more complex than it seemed in the early enthusiasm. The first promoters underestimated the complications and the significance of the endeavour. Originally, it was believed that a convention banning future production would be simple to be accomplished. India too, which has produced large amounts of fissile materials in the past, seemed interested in preventing further production in Pakistan and other states. An FMCT appeared to be an easily achievable additional arms control measure, well suited to be celebrated as a nuclear disarmament concession and at the same time inserting some restraints and controls in the states outside the NPT. However, not only the inherited conflict on nuclear disarmament has escalated more than expected, the FMCT is also more complex than probably anticipated by the early proponents. One reason is the *principle of nondiscrimination*, that has been included in all international documents on a cutoff, in contrast to the original U.S. proposal.[6] This means that scope and verification must apply similarly for all parties, for NWS as well as for nonnuclear weapon states (NNWS) and states outside the NPT (SON)[7]. It implies that no special exceptions or provisions for one group of members can be allowed, including verification. The ban of the "production of fissile material for nuclear explosive purposes or outside of international safeguards" is the same as that being verified in NNWS by the International Atomic Energy Agency (IAEA) in order to ensure their compliance with the NPT. Explaining why a weaker verification is sufficient to ensure compliance with an FMCT but not sufficient to ensure the NNWS's compliance with the NPT might be difficult. Yet it may be doubted if such an intrusive verification as that of the NPT will be acceptable for all NWS, even less for the SON.

Another demand has also complicated the enterprise, and even right from the beginning, already during the struggle for agreement on the wording of the mandate: Considerable difficulties arose when some countries, particularly Pakistan, Algeria, Iran, and Egypt insisted on including existing stocks of nuclear material into the mandate text. Others, especially the NWS – at that time still jointly in one mind with India – emphasised that the consensus in the UN cov-

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[4] UN Press Release DCF/287, 18 February: Conference on Disarmament adopts agenda for 1997.

[5] The developments in the CD have been described in detail by R. Johnson in the reports of the Acronym Consortium and the periodicals Nuclear Proliferation News (until the end of 1995), and Disarmament Diplomacy (starting January 1996). For an overview on the CTBT see A. Schaper, The Comprehensive Test Ban Treaty from a Global Perspective, in: M. McKinzie (Ed.), Issues Surrounding U.S. Ratification of the Comprehensive Test Ban Treaty, Cornell Conference proceedings, forthcoming 1997.

[6] White House Fact Sheet On Non-Proliferation And Export Control Policy, September 27, 1993.

[7] There are eight SON, those of geopolitical importance are Brazil, India, Israel, and Pakistan. The latter three are suspected of a nuclear weapons capability, Brazil is bound by its commitments under the Tlatelolco Treaty.

ered only negotiations on future production but not on existing material. After intense consultations and skilful diplomacy, the CD finally agreed on the mandate text which incorporates the "ban of production of fissile materials for nuclear weapons or other nuclear warheads", but additionally left open the option to include other issues into the negotiations such as how to deal with existing material. They agreed to disagree on the stockpile issue.[8] In case of existing stocks not being included, it must at least be ensured that material produced later is not simply declared as earlier production. And to guard against civil material being recategorised as military, an FMCT can have the effect to cap the amount of existing military material, e.g. make nuclear disarmament truly a one-way road. The consequence is again that verification must extend to all existing civilian and military production facilities, including also light-water reactors, similarly as in NNWS.

Excluding existing stocks might cause an additional complication - it could be read as legitimizing previously produced material. In the view of many observers, this could imply indirectly a recognition of the right of SON to own such uncontrolled military stocks. These countries would at least obtain a privileged status compared with the NNWS Parties to the NPT.[9] However, it can be questioned whether a different status is not already the reality, and whether this is not a price that must be paid for the SON's participation.

In sum, the initial optimism has been replaced by disappointment. The designated negotiation forum, the CD, is deadlocked; the interests, the scope and the verification of any potential FMCT seem utterly unclear, and the task looks more difficult than originally expected. Should therefore the whole endeavour be postponed or even be abandoned? Is an FMCT one disarmament measure that can be sacrificed, and would the damage caused by doing so only produce some complications at the next NPT review conference which could be contained somehow? Or should it be recommended to implement some simple measures such as placing some U.S. and Russian excess fissile material under international safeguards and sell this as an FMCT convention, as an attempt to satisfy the review conference? Or would this be a waste of the potential that an FMCT offers for much more fundamental global reforms?

This report is based on the assumption that the time has come for more control of fissile materials. For the next decades to come, the international community must combine efforts to deal with increasing amounts of unsufficiently secured fissile materials stemming from nuclear arms reductions. Further nuclear reduction agreements beyond START II are likely.[10] Substantial reforms of the IAEA's safeguard systems are already underway, due to lessons from the past. New transparency measures on plutonium are being negotiated in Vienna. They are understood as a beginning for even more universal reforms. The concerns about reducing military material and about more global controls have gone beyond only national decision making, and the time is ripe for the introduction of regulatory measures also in the NWS, and for the creation of a fundamental, new concept of how to deal with fissile materials.[11] Pressure in this direction can-

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[8] S. Lodgaard, A Fissile Material Cut-off, Paper submitted for the Twentieth PPNN Core Group Meeting, 25-27 October 1996, Princeton, USA, second draft of December 12, 1996.

[9] See D. Fischer, Some Aspects of a Cut-off Convention; in: Unidir Research Papers No 31: Halting the Production of Fissile Materials for Nuclear Weapons, Geneva 1994.

[10] R. J. Smith, More nuclear disarmament beyond START II is expected, Washington Post, January 23, 1997.

[11] A persuasive discussion of the necessity and of proposals is in: D. Albright, F. Berkhout, W. Walker, Plutonium and Highly enriched uranium 1996 – world inventories, capabilites and policies, SIPRI, Oxford Univeristy Press, 1997, see Chapter 15: The control and disposition of fissile materials: the new policy agenda.

not be put on hold indefinitely. A cutoff will be part of a new concept, and it would be a great mistake to abandon the idea.

Two prerequisites for progress are necessary: One is to overcome or to circumvent the current deadlock in the CD. The other is to address the complex questions of scope and verification. A difficulty of the second task is the interdisciplinary nature of the subject that involves political, technical, legal, and economic aspects and that constitutes a challenge for diplomats and decision makers. Potential positions on scope and verification are influenced by various interests, political circumstances, and related events, e.g. the experiences from the CTBT negotiations, pressure created by the Principles and Objectives of NPT reviews, potential verification costs, legal ranges of existing safeguards, or the safeguards reforms. The goal of this report is mainly to contribute to the second prerequisite. Its central topic is an analysis of the possible variations of the scope and an outline of verification tasks and scenarios. In a first chapter, the origin of the cutoff is addressed which was influenced by events in and outside the CD, and current reforms of international fissile material controls. The other main chapters cover overviews on the variations of scope and safeguards. Finally, an attempt will be made to find recommendations for the governments of industrialized NNWS, especially Germany as an important example, and more generally also for the international arms control community.

2 The origin of the Cutoff

2.1 Events outside the CD

Originally, a cutoff of fissile materials for weapons was part of the 1946 Baruch Plan that aimed at implementing a strong control regime on fissile materials but never became reality. It was next proposed by India in 1954, together with proposals for world wide nuclear disarmament and a nuclear test ban treaty.[12] But the proposal did not get any reaction, it was rejected without any further discussion. It was proposed again by Eisenhower in 1956, but refused by Moscow as a tactic to freeze an inferior Soviet status.[13] Gorbachev made the proposal in 1989, but it was rejected by Bush. Since 1978, the proposal was supported by many UN General Assembly resolutions as a prerequisite for nuclear disarmament, but in contrast to the fame of a CTBT it was treated rather just as a wallflower.

The turning point in the U.S. rejection of an FMCT came on September 27, 1993, when President Clinton addressed the UN General Assembly proposing a multilateral agreement to halt production of HEU and separated plutonium for nuclear explosives or outside international safeguards.[14] This led to the topic on the UNGA agenda[15] in November, and a consensus resolution calling for the start of negotiations on a non-discriminatory and universal cutoff convention on December 16. On December 15, the German Foreign Minister published the 10-Point-Initiative, outlining the goals of German nonproliferation policy, which also includes a call for a ban on production of fissile materials for weapon purposes.[16] In January 1994, the topic was placed on the agenda of the CD.

At that time, other nuclear arms control activities had much higher a priority, namely the CTBT and the review and extension conference of the NPT which adopted the Principles and Objectives for future reviews. They explicitly list a non-discriminatory and universally applicable FMCT together with the CTBT as nuclear disarmament measure that must be successfully pursued.[17] This was the last impetus that has put the topic irreversibly on the nuclear arms control agenda. The Principles and Objectives were the price for the indefinite extension of the

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[12] D. Cortright, A. Mattoo, Indian Public Opinion and Nuclear Weapons Policy, in: D. Cortright, A. Mattoo (Ed.), India and the Bomb, University of Notre Dame Press, 1996.

[13] S. Fetter, F. v. Hippel, A Step-By Step Approach To a Global Fissile Materials Cutoff, Arms Control Today, October 1995, p. 3-8.

[14] "…Growing global stockpiles of plutonium and highly enriched uranium are raising the danger of nuclear terrorism for all nations. We will press for an international agreement that would ban production of these materials for weapons forever…". Reprinted in: Arms Control Reporter, Chronology 850-109. Original text in New York Times, September 28, 1993, p. A16.

[15] UN General Assembly, 48th Session, First Committee, Agenda item 71 (c), November 8, 1993.

[16] Summary in: Nuclear Proliferation News, Issue No. 5 - Friday, 10 June 1994.

[17] Principles and Objectives for Nuclear Non-Proliferation and Disarmament: "The achievement of the following measures is important in the full realization and effective implementation of article VI, including … The immediate commencement and early conclusion of negotiations on a non-discriminatory and universally applicable convention banning the production of fissile material for nuclear weapons or other nuclear explosive devices,…".

NPT.[18] Similarly to the CTBT, finally also a cutoff has become an explicit symbol for comprehensive nuclear disarmament, and the attention given to it will be regarded as an indicator of how seriously this ultimate goal is being taken, and it will affect the future good will of those who had reservations about the indefinite extension of the NPT.

2.2 The struggle for a mandate in the CD

The establishment of an Ad Hoc Committee in the CD with a mandate to negotiate a fissile material cutoff treaty struggled with difficulties for more than a year. The central dispute was whether the mandate should refer to existing unsafeguarded stockpiles. Although the UNGA resolution only refers to banning future production of material, Algeria, Egypt, Iran, and Pakistan held out for an explicit reference to stockpiles.[19] Also a group of non-aligned states had jointly and repeatedly called for a fissile material cut-off to include declaration and control of stocks, advocated also by several Western and Eastern European states concerned about nuclear smuggling. But Israel and India, as well as France and the UK, have indicated that they would not enter into negotiations that included stocks. Also the U.S. whose major interest is to bind the three SON into a cutoff, rejected the reference to existing stockpiles because this would have reduced the likelihood to achieve this goal. But India’s large stocks are the major reason why Pakistan finds it important to include them in negotiations. Also many other delegations, including Germany, found it important at least to ensure that no civilian material can go back into the military cycle. However, for the sake of getting started, they would have accepted any mandate text, provided that it did not prejudice already a treaty scope.[20]

Finally, on 23 March 1995, the Canadian Ambassador Shannon presented a carefully crafted text announcing that a consensus had been reached to establish an ad-hoc-committee with a mandate based on the UNGA text. Although this mandate did not refer to stockpiles, the text explicitly states that discussions on the appropriate scope of the treaty are not excluded, and it also mentions the questions raised by some delegations regarding past production.[21] This text – similarly as the UNGA resolution and the Principles and Objectives – refers to the *principle of nondiscrimination* of an FMCT. This is different from the original U.S. proposal that does not make any reference neither to discrimination nor to nondiscrimination.

However, mainly because the CD was overburdened by the CTBT work, the negotiations have been delayed. Another reason was Pakistani resistance against the proposed chairman. Meanwhile, the mandate has expired, and the situation has changed, because of the CTBT experiences.

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[18] On the commitments by NWS and NNWS implied by the Principles and Objectives see: H. Müller, Far-Reaching Nuclear Disarmament, Unidir NewsLetter, Number 31/95, p. 31.

[19] All information on the developments in the CD described here is also reported in: Nuclear Proliferation News, No. 1-37, 1994-1995. See also R. Johnsohn, Fissile Cut-off, Acronym No. 6: Strengthening the Non-Proliferation Regime: Ends and Beginnings, p. 20, April 1995.

[20] See Ambassador W. Hoffmann, Basic Obligations and Scope of the Cut-off Convention, Paper presented at a workshop held in Toronto from 17 to 18 January 1995.

[21] Report of Ambassador Gerald E. Shannon of Canada on Consultations on the Most Appropriate Arrangement to Negotiate a Treaty Banning the Production of Fissile Material for Nuclear Weapons or Other Nuclear Explosive Devices, reprinted in Nuclear Proliferation News, No. 21, 4 April 1995.

2.3 Lessons learned from the CTBT negotiations

The CTBT and an FMCT can be compared in many aspects: both are major nuclear disarmament symbols, qualitative or quantitative, respectively; both are explicit commitments by the NPT members, laid down in the Principles and Objectives; both also have a nonproliferation component; and both have been triggered by new realities after the end of the Cold War, notably the ending of U.S. and Russian testing and the lack of need for new material. Therefore, many interests and conflicts apply similarly to both. The CTBT has been negotiated in the CD, the same forum that has been chosen for the FMCT. However, the major difference between them is that lessons learned from the CTBT negotiations will strongly influence any future FMCT negotiations.[22] They are the major reason for the current deadlock, because in contrast to the start of the CTBT negotiations, now the conflicts lay on the table – openly, escalated, and unsolved.

At the start of the CTBT negotiations, an underlying conflict could also be seen, but it was not taken very seriously. It can be summarized as *nuclear disarmament versus nuclear nonproliferation*, although the majority of the negotiation partners wanted both.[23] The NWS were mainly motivated by the prospect of nonproliferation, e.g. the curbing of any future nuclear weapon developments by the SON, including the development of thermonuclear designs in the cases of India, Israel, and Pakistan. At the same time, they were interested in minimizing their own restrictions as much as possible.[24] An example is that they even rejected a simple preamble language stating that the goal of the treaty is the end of the qualitative arms race.[25]

India, a major target of the efforts by the NNWS, had the perspective that the NWS demanded far more from the SON than they were willing to give in return. Throughout the negotiations, it stressed the disarmament component, in a way that during the two and a half years became more and more radical. It culminated in the demand for a timetable for comprehensive nuclear disarmament. This goes far beyond any traditional perception of what constitutes a test ban, and was unacceptable to the other participants, mainly because it was unacceptable for the NWS and everybody knew that insisting would deadlock the negotiations.[26] It is conceivable that India was not interested in successfully finishing this round of negotiations and tried to put the blame on others. Domestically, pressure was exerted to undertake some nuclear tests thus demonstrating that it is a nuclear weapon state.[27]

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[22] An important source for this section is Appendix I: Some striking similarities and some telling dissimilarities between a cutoff convention and a CTBT, by S. Keller.

[23] On the interests and results of the CTBT negotiations see: A. Schaper, Der Umfassende Teststoppvertrag: kurz vor dem Ziel – oder gescheitert?, HSFK-Standpunkte, Nr. 7, August 1996; An English version is: A. Schaper, The Comprehensive Test Ban Treaty from a global perspective, in: M. McKinzie (Ed.), Issues Surrounding U.S. Ratification of the Comprehensive Test Ban Treaty, Cornell Conference proceedings, forthcoming 1997.

[24] It must be emphasized, however, that the scope of the CTBT turned out to be more rigourous than observers had realisticly expected, caused by events that were triggered by the timely coincidence of negotiations on scope and the international pressure on France because of its resumption of nuclear testing. The CTBT in fact is now a good tool for curbing the qualitative arms race. See Schaper, fn. 23.

[25] R. Johnsohn, Comprehensive Test Ban Treaty: The Endgame, Acronym No 9, April 1996.

[26] See P. Bidway, A. Vanaik, After the CTB… – India’s intentions, The Bulletin of the Atomic Scientists, p. 49, March/April 1997.

[27] See for example: Brahmah Chellaney, If pushed over Test Ban Pact, India could really ‘Go Nuclear’, IHT, 7-8 September 1996.

The NWS made the mistake of not granting any single concession to India, such as acceptance of India's proposal on the preamble language. Therefore, any face-saving compromise had become virtually impossible in view of the strong domestic backing. India's final declaration was therefore logical that it was not in a position to sign or even ratify a treaty which had been entirely dictated to it and reflected none of its demands. This mistake is the more difficult to comprehend because a concession would have robbed India of an important argument. Its adopted role of disarmer would have appeared less credible and if it would still have resisted to accept compromises, the hypocritical nature of its position would have become more clear. If one takes the view that concessions would have had no purpose because India would not have signed anyway, it is illogical on the other hand to believe that India could have been forced to sign by international pressure.

This conflict escalated at the end on the question of entry into force (EIF), when the UK, Russia, and China insisted on the condition of ratification by a list of states including the SON, and especially India, before letting the treaty enter into force.[28] Such a position is logical if the main interest relates only to non-proliferation: better to have no treaty than one in which the non-proliferation component, namely membership of the SON, is not bound. India, claiming that inclusion of such an EIF clause was tantamount to coercion, even blocked the consensus in the CD to submit the draft treaty text to the UN – in vain, as it turned out, because this deadlock was circumvented by a group of states who submitted the text independently from the CD.[29]

Also regarding the FMCT, it must be expected that the NWS are interested in including India and the other SON. John Holum, Director of the U.S. Arms Control and Disarmament Agency (ACDA) expressed this very clearly: "The fissile cutoff is our best hope of capping the nuclear weapon potential of countries outside the NPT, including India and Pakistan."[30] It may be expected that they place a comparably high priority on this goal also in FMCT negotiations. Chinese publications on the subject list two goals: to "prevent the spread of nuclear weapons" and progress "towards comprehensive … nuclear disarmament."[31] Also the French Government sees the major benefit in nonproliferation: T. Delpech (formerly French Commissariat à l'énergie atomique) can imagine a favourable position of France and Britain towards negotiations, "provided at least that the benefit in terms of non-proliferation is clear", which to her means the participation of these three SON.[32]

Several lessons for cutoff negotiations have been learned from the CTBT experiences:

- India has learned that it was not able to influence the negotiations towards more disarmament commitments, neither with sensible proposals nor with radicalization of its positions. It was also unable to take the lead of the group of nonaligned (NAM), because they did not follow India's radicalization. The NAM preferred any treaty to none, therefore they were willing to compromise. Even India's veto did not prevent the unaccepted

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[28] R. Johnson, Geneva Update – A summary of negotiations, Disarmament Diplomacy, No 6, June 1996.

[29] The CD adopts its decisions by consensus, so every member has a veto power.

[30] J. Holum, Congressional Research Service, seminar on arms control, January 9, 1997.

[31] See for example: Chen Xueying and Wang Deli, The Top Priority of Current Nuclear Arms Control, Paper for the 5th ISODARCO-Beijing Seminar on Arms Control, 11-16 November, 1996, Cheng-Du. China; Tian Dongfeng, Controlling the Spread of Weapon Usable Fissile Materials, in: Arms Control Collected Works, Program for Science and National Security Studies, Institute of Applied Physics and Computational Mathematics, Beijing, 1995.

[32] Delpech, Thérèse; A Convention on the Prohibition of the Production of Fissile Material: Uncertain Benefits for Nonproliferations; in: Unidir Research Papers No 31: Halting the Production of Fissile Materials for Nuclear Weapons, 1994.

text to be opened for signature. So no expectation that India might have had in the beginning, had been fullfilled, instead it has found itself without any presentable success, more isolated than before, and under more international pressure. Therefore any incentives to engage again in similar negotiations have faded. Worse still, it is likely that India will do everything to prevent them from getting started in order to avoid a repetition of this experience. This uncooperative behaviour can be observed now in the CD.

- The U.S. and the other NWS, whose original cutoff motivation was mainly to include India and the other SON have learned that this goal can hardly be met anymore. They now realize that they have underestimated India, and that India's cooperation has become very unlikely.[33] Now they see that it has become very difficult to repeat the CTBT procedure. Therefore, their enthusiasm has cooled down, and their other motivations for an FMCT are much weaker, similarly as their other motivations for the CTBT apart from nonproliferation are weak.
- Everybody has also learned the lesson that the CD as negotiation forum has become problematic, because of the consensus principle and the lacking good will for cooperation of some major participants. Also now, concessions are not in sight, as they were lacking during the CTBT negotiations. The stalemate could perhaps be cracked by the implementation of a negotiation or discussion forum on nuclear disarmament, but the willingness of the NWS is lacking.
  The value of the FMCT as an arms control and disarmament measure, beyond its value as a non-proliferation measure, has been underestimated in the NWS – partly deliberately. An FMCT would involve considerable administrative effort to implement, and would require changes in attitudes and behaviour, especially regarding multilateral verification within the NWS. The emphasis on non-proliferation has thus been a useful means, for some constituencies, of lessening the likelihood that an FMCT will ever be negotiated.[34]

2.4 Other new initiatives on fissile material – heralds of a paradigm change?

In contrast to the CTBT negotiations, negotiations on an FMCT must take into account several other international activities closely related to its subject. The reason are the different technologies concerned and their related interests. Most of what is banned by the CTBT, e.g. nuclear testing, is unambiguously military and hardly relevant for important civilian applications. The overlap between military activities close to testing and legitimate civilian research and technology is only narrow, e.g. only a few dual-use activities such as inertial confinement fusion or computer simulations are affected by the suspicion that they might be misused for

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[33] On India's nuclear policies see: W. Walker, India's Nuclear Labyrinth, The Nonproliferation Review, p. 61, Fall 1996; G. Perkovich, India's Nuclear Weapons Debate: Unlocking the Door to the CTBT, Arms Control Today, p. 11, May/June 1996; A. Mattoo, India's Nuclear Status Quo, Survival, Vol. 38, No. 3, Autumn 1996, p. 41; M. V. Ramana, India's Participation in a Fissile Material Production Cutoff Convention, Paper presented at the Eighth International Summer Symposium on Science and World Affairs, Beijing, China, July 23-31, 1996; P. Bidwai, India's post-CTBT cynicism: why New Delhi could be a spoiler at the CD again, Disarmament Diplomacy, No 12, p. 2, January 1997; J. Singh, Current issues of nuclear proliferation: Geopolitical aspects – A perspective from India, Paper prepared for presentation at the Symposium on the Extension of the Nuclear Non-proliferation Treaty, Foundation Pour Les Etudes De Defense, and CER, Paris, February 10-11, 1995.

[34] I owe this point to W. Walker.

undermining the treaty's spirit.[35] No special verification is planned for these ambivalent technical activities.[36] Therefore, not many interests are involved that are not directly related to nuclear weapons. This is different with an FMCT, because the dual-use problem is endemic where fissile materials and their production technologies are concerned. They are similarly important for civilian nuclear energy as for military use. Therefore, an FMCT affects many related interests which can be summarized as minimizing restraints on civilian industry versus strengthening nonproliferation and disarmament. In the last years, several efforts have been started to cope with the related problems or conflicts: there are international efforts to strengthen the security of materials and technologies stemming from the former Soviet Union's nuclear weapon complexes, negotiations on Guidelines for the Management of Plutonium (GMP), and the reform of the IAEA safeguards, known by the name of "93+2". These initiatives will be shortly described in the following.

2.4.1 Security and transparency of fissile materials from nuclear disarmament and of the nuclear weapon complexes

As a consequence of the nuclear disarmament in the U.S. and in Russia, hundreds of tons of HEU and Pu from dismantled nuclear warheads will be released and will become excess of the military cycle.[37] This creates new concerns. It must be ensured that even tiny fractions of this huge amount of weapon grade material cannot be diverted by unauthorized groups, such as a potentially well organized mafia which could transfer it into the hands of states with nuclear ambitions or even of terrorists. Another danger would arise if Russia's democratic development would not remain stable and any undemocratic successor could reuse the material rather easily.[38] The security of the Russian nuclear production complex is estimated to be far below Western standards and in danger of deteriorating even further, so that the probability of proliferation is high.[39] The problems have proven so huge and costly that it is not possible for Russia to cope with them without international assistance.

Several international or bilateral studies and activities have been started to encounter these problems. One set of initiatives aims at physical protection of materials and installations, secu-

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[35] A. Schaper, The problem of definition: Just what is a nuclear weapon test? In E. Arnett: Implementing the Comprehensive Test Ban, SIPRI Research Report No. 8, Oxford 1994.

[36] There are several reasons: verification is either practically not possible, or not worth the effort, or not wanted because the technical activity can be confused with allowed military activities such as maintaining the stockpile or conventional military research.

[37] For an overview on the security of the Russian nuclear complex see: O. Bukharin, Security of fissile materials in Russia, Ann. Rev. Energy Environ., Vol. 21, p. 467-496, 1996.

[38] The problem of excess Pu and its disposition options have been studied in detail by: National Academy of Sciences (NAS), Committee on International Security and Arms Control (CISAC), Management and Disposition of Excess Weapons Plutonium, Washington 1994; NAS, CISAC, Management and Disposition of Excess Weapons Plutonium: Reactor Related Options, Washington 1995.

[39] W. C. Potter, Before the Deluge? Assessing the Threat Of Nuclear Leakage From the Post-Soviet States, Arms Control Today, October 1995, S. 9-16; A. 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, June 11-13, 1997, proceedings forthcoming 1997; V. 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, April 7-8, 1997.

rity of transports, implementation of material accountancy,[40] reforms of export controls[41] and border controls, and conversion of jobs in the military nuclear complex.[42]

A second set of initiatives aims at the nuclear disarmament process itself. Elements are the dismantling of warheads, the construction of secure storage sites, and technical solutions for the disposition of fissile material. The largest assistance program for both kinds of activities is the *Cooperative Threat Reduction* (CTR) which is funded by the U.S. with more than 1 billion U.S.-dollars.[43] The latter group of initiatives, the international nuclear disarmament cooperation, has to cope with two kinds of political problems: the harmonization of different civilian nuclear policies, and the struggle for verification and transparency.

While the civilian use of HEU is undisputed[44], the international collaboration in the disposition of plutonium has to deal with the problem that nuclear policies of major actors, especially the U.S. and Russia, are very different from each other and largely incompatible: Russia would like to start an extended plutonium economy, including fast breeders and new civilian plutonium production. The Russians reject the idea of disposition of their excess weapons plutonium without commercial benefit. The U.S. on the contrary has renounced any civilian plutonium recycling since the Carter administration because of economic and proliferation concerns.[45] They also have the official policy to discourage others and not to support any recycling activities abroad. However, for the disposition of the U.S. weapons plutonium, a double approach has been chosen: the technologies of direct disposal of vitrified high level waste and of burning

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[40] W. Sutcliffe, A. Rumyantsev, The Accounting and Control of Nuclear Material and Radioactive Substances in Russia, Yaderny Kontrol, English Digest, No. 1, Spring 1996.

[41] E. Kirichenko, Evolution of the Russian Nonproliferation Export Controls, The Monitor, Vol. 2, No. 3, p. 8, Summer 1996.

[42] For this purpose, the International Science and Technology Center has been implemented that aims at funding civilian projects with international collaboration involving scientists from the Russian nuclear weapons complex. See: The International Science and Technology Center, January – December 1995, Second Annual Report, Moscow 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, S. 29, January 1995; 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, 31 March 1997.

[43] Department of Defense, 1996 Annual Defense Report, Chapter 8: Cooperative Threat Reduction; The White House Fact Sheet: U.S. Nunn-Lugar Safety, Security, Dismantlement Program, March 21, 1994; U.S. General Accounting Office (GAO), Weapons of Mass Destruction: Status of the Cooperative Threat Reduction Program, Letter Report, 09/27/96, GAO/NSIAD-96-222; for assessments see: J. E. Stern, U.S. assistance programs for improving MPC&A in the former Soviet Union, The Nonproliferation Review, Vol. 3, No. 2, p. 17, Winter 1996; and O. Bukharin, U.S. cooperation in the area of nuclear safeguards, The Nonproliferation Review, Vol. 2, No. 1, p. 30, Fall 1994.

[44] The technical procedure is clear: the HEU will be diluted to low enriched civilian reactor fuel. Problems with HEU transfer into civilian use arise only from economic complications: see R. A. Falkenrath, The U.S.-Russian HEU Purchase Agreement: Achievements, Problems, Prospects; Report of the Center for Science & International Affairs, Harvard University, July 1995.

[45] On technical properties of fissile materials and their usefulness for military or civilian applications see section 3.1.1: Classification of materials.

the fuel as mixed oxide (MOX) in light water reactors are planned to be pursued in parallel.[46] Both options fulfill the best a list of criteria, including comparatively high proliferation resistance, short time scale (still in the range of decades), technical feasibility, environmental protection, and lower costs. An important reason for the American MOX choice is also that this could be acceptable for the Russians, and therefore enable joint U.S.-Russian projects. This said**,** the U.S. does not intend to restart any commercial Pu recycling or to change the nuclear policy principles. Indeed, because of this common denominator, finally more substantial collaboration on disposition has started that so far has found its first result in a voluminous joint study.[47] Also noteworthy 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 P8 Nonproliferation Experts Group in November 1996.[48]

All disposition projects also aim at enhancing international transparency. Any German participation and collaboration is only possible under international safeguards.[49] The U.S. is so far the only NWS that has already put some declared excess material under IAEA safeguards.[50] As the Moscow P8 nuclear summit in spring 1996 concluded, IAEA safeguards should be applied to the material *"as soon as is practicable to do so"*[51]. This latter addition, of course, weakens the commitment substantially because the "practicable" allows wide interpretations and has the potential to change the meaning into *"never"*. Yet this official statement by the P8 can mark a historic turn in traditional principles of the nonproliferation regime.

Also important are joint U.S.-Russian efforts to construct a storage facility at Mayak for fissionable material from dismantled nuclear weapons.[52] If construction continues as currently anticipated, the facility could begin storing its first 25,000 containers in 1999 and be entirely completed in 2001. While the design and construction of the Mayak facility have progressed over this year, the United States and Russia have problems with transparency arrangements for the facility. Russian officials appear to have agreed to Mayak transparency in principle. They have indicated that the facility will be transparent to the U.S. and stated that it will provide for "joint accountability and transparency measures permitting confirmation by the U.S.". In doing

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[46] D. Airozo, It's official: DoE pursues dual strategy to dispose of excess weapons Pu, Nuclear Fuel, January 27, 1997. This double track had first been recommended by the NAS-studies (fn. 38), a study by the DoE follows similar lines: Draft Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Plutonium Disposition Alternatives, DoE, Office of Arms Control and Nonproliferation (NN-40), October 1, 1996.

[47] Joint U.S./Russian Plutonium Disposition Study, prepared by the Joint U.S.-Russian Plutonium disposition Steering Committee, September 1996.

[48] A. MacLachlan, French, Germans and Russians aim for 1998 decision on MOX plant; Nuclear Fuel, Dec. 2, 1996; National Academy of Science and German-American Academic Council (GAAC): U.S.-German Cooperation in the Elimination of Excess Weapons Plutonium, 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: A. Schaper, Using Existing European MOX Fabrication Plants for the Disposal of Plutonium from Dismantled Warheads, in: W.G. Sutcliffe (Ed.), Selected Papers from Global '95, UCRL-ID-124105, Livermore, June 1996, p.197

[49] See GAAC study, fn. 47.

[50] F. v. 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, 12 - 15 November, 1996. See Table 2: Inventories of Pu and HEU inside and outside nuclear weapons.

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

[52] Source for the two paragraphs on Mayak and STI: GAO Report, fn. 43.

so, they appeared to link these pledges to reciprocal U.S. pledges. But U.S. officials have held that U.S. transparency rights derive from U.S. funding and would not result in reciprocal Russian access to U.S. storage facilities.

Parallel to these activities have been the broader *Safeguards, Transparency, and Irreversibility (STI) negotiations* between the U.S. and Russia. STI would have addressed Russian concerns regarding reciprocity by establishing (1) reciprocal inspections to confirm each nation's stockpiles of highly enriched uranium and plutonium from dismantled nuclear weapons, (2) data exchanges on nuclear warhead and fissile material stocks, and (3) cooperative arrangements to monitor excess warheads awaiting dismantlement. However, the STI talks ceased in late 1995. Yet DOE and MINATOM agreed in early 1996 that Mayak transparency efforts would proceed regardless of STI's status. After several years of hesitation, Russian officials have also suggested that they will place the facility under IAEA safeguards. Meanwhile, trilateral U.S.-Russian-IAEA talks have begun on IAEA verification of declared excess materials, which must be appreciated as a very remarkable progress.[53]

2.4.2 Guidelines for the Management of Plutonium

While these transparency efforts have only been bilateral so far, international negotiations on enhancing the transparency, security, and control on plutonium have been taking place in Vienna, under the name of *Guidelines for the Management of Plutonium* (GMP), or *International Plutonium Management*. They have been triggered by concern because of the increasing amount of world wide plutonium transfers and by the huge amounts of plutonium from dismantled weapons that are currently without international controls. A last incentive was the criticism of the plutonium shipments for Japan, and a Japanese initiative to create more confidence in their nonmilitary intentions.[54] Japan's interest is clearly to appease international concerns by creating more transparency and at the same time to secure international tolerance of its civilian plutonium industry.[55]

In contrast to the cutoff, the actors in the negotiations on a GMP are so far limited to a small number of those countries that have substantial civilian nuclear industry: the nuclear weapon states, and Japan, Germany, Switzerland, Belgium, with the IAEA and Euratom acting as observers. However, in case more progress is made, the process could be transformed in broader negotiations which after all will also concern all IAEA and Euratom members.

The possibility of an International Plutonium Storage is already foreseen in the IAEA statute (Art. 12 A 5). The idea was to store superfluous material under international authority and only to release it for immediate civilian use. This would further reduce the risk of diversion for military purposes and enhance the confidence in the peaceful intentions of civilian plutonium economies.[56] From 1978 to 1982, negotiations in the framework of the IAEA took place but failed because no agreement on the conditions for release of materials could be reached, India

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[53] Department of Energy, Press Statement: Trilateral Initiative on Verifying Excess Weapon Origin Fissile Materials, November 8, 1996; B. 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, 12 February 1997.

[54] N. Usui, Oyama says Japan will discuss International Plutonium Management, Nucleonics Week, March 4, 1993.

[55] Shinichiro Izumi, International Management of Plutonium, Plutonium No. 12, p. 3, Winter 1996.

[56] A very detailed but old analysis reflecting the American interests is: Charles N. Van Doren, Toward an International Plutonium Storage System, Report prepared for the Congressional Research Service, No. 81-255 S, November 1981.

again being one of the main opponents. Several states feared that their national sovereignty and flexibility would be excessively limited.

Various incentives and favourable conditions caused the resumption of discussions: In the end of 1992, IAEA Director General Hans Blix took the initiative and invited several states to discussions. Together with his UNGA declaration in September 1993 in favour of an FMCT, President Clinton also declared that the problem of plutonium disposition was central and that the U.S. was willing to put excess weapons plutonium under the US-IAEA voluntary Safeguards Agreement.[57] Also German Foreign Minister Klaus Kinkel called for an International Plutonium Regime in his 10-Point Initiative in December 1993.[16] The idea behind is not storage but a more secure way of managing the civilian use of plutonium. Meanwhile, the UK and Japan have taken the lead in publishing detailed figures of their civil plutonium stocks.[58]

The negotiations are now in their final stage. The guidelines will deal with safeguards, radiological protection, physical protection, nuclear material accountancy and control, international transfers, management policies, and transparency.[59] They go beyond existing agreements especially because of commitments to continuously adapt to the most modern standards, and because of the improved transparency of stocks: annual declarations will give overviews on detailed figures of all kinds of unirradiated civil plutonium. However, for China this is still difficult to accept, because it still finds any obligations concerning its fuel cycle too intrusive. The major improvement that will result from these guidelines is the fact that similar obligations are also put on the NWS, especially the obligation to submit plutonium from former military use under international safeguards. However, it is not surprising that it is heavily contested how binding these commitments are. This is reflected in disputed language: no agreement has been reached if plutonium shall be affected by the guidelines after it has been *"designated"* or *"declared"* as no longer required for defense purposes. This wording has a strong impact on how binding the obligations are. Also the reservation *"as soon as practicable"* similar as in the P8 summit declaration has been proposed again but is disputed. These problems can be compared to the problems in the U.S.-Russian talks on STI and the transparency of the Mayak facility (see section 2.4.1). The idea of being subjects to controls themselves is still new to the NWS and has to overcome conservative inertia. At least France’s and Britain’s civilian fuel cycles are already under Euratom safeguards, and they have no difficulties to accpt the obligations under the GMP all the more as they do not intend to declare any Pu as excess to their defense need. But the other NWS having never before experienced regular safeguarding still are – to different extents – reluctant to commit themselves to IAEA safeguards, and use the difficulties of providing a clear cut separation of their military and their civil fuel cycles as a pretext. A similar discussion on "Guidelines for the Management of HEU" can be foreseen as some participants in the GMP talks prefer to extend this activity to HEU as well. The GMP will probably constitute the first international agreement that puts control obligations on all NWS. It will affect

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[57] Fred McGoldrick, US Fissile Material Initiatives, Invited Paper, Procedings of the Symposium on International Nuclear Safeguards, Vienna, 14-18 March 1994, p. 17. On the voluntary safeguards see chapter 4: Verification.

[58] N. 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, February 1996. The Japanese figures are published annually since 1995: Info-clip, Plutonium Inventories in Japan, Plutonium No. 11, p. 15, Autumn 1995. EU members do not have national nuclear material accountancy, this authority has been transferred to Euratom (cf. Appendix II: Euratom and other regional safeguards systems and their potential roles in a cutoff).

[59] 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.

areas that previously had been exclusively under national controls and untouched by international regulations.

2.4.3 The 93+2 safeguards reforms

On May 15, 1997 the IAEA and its member states adopted new safeguards arrangements for strengthening the effectiveness and improving the efficiency of the safeguards system which has become known by the name 93+2.[60] They are significant for an FMCT because they will set new standards of what is a satisfactory verification of the absence of production of fissile materials for weapon purposes. They were triggered by the cases of Iraq[61] and North Korea[62] whose clandestine acquisition activities have demonstrated that the former nonproliferation tools and efforts were not sufficient. Therefore, attempts have been intensified to reform national and international institutions and measures such as safeguards and export controls.

Whereas the traditional IAEA safeguards had the major goal of verifying compliance with commitments, the 93+2-reforms seek to allow the IAEA to detect noncompliance, e.g. undeclared activities at an earlier stage. The reforms consist of two parts: part I contains changes that could be implemented already in 1995 by the Board of Governors because they were covered by existing legal authority, but part II needed additional legal authority, and therefore new legal provisions that had to be negotiated between the IAEA and the member states. It has resulted in a new "Model Protocol Additional to Existing Safeguards Agreements".

The protocol contains several elements: they include access beyond nuclear sites, using the existing right to access on "short notice" or "no notice" during routine inspections, 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 nuclear facilities. This includes technologies that constitute important elements in the nuclear fuel cycle infrastructure, such es components of centrifuge enrichement technology. Also exports and imports of such technologies are asked to be declared, as well as ongoing research. Another component of the reform is taking environmental samples not only at an inspected facility which is already legal but also in the vicinity under certain circumstances. 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 in depicting a proliferation or nonproliferation profile of a state. Another new element is expanded access, e.g. to sites contained in the expanded declaration, to decommissioned sites, and also to other sites than those

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[60] 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. The proposals made by the IAEA are described in: S. van Moyland, Verification Matters: The IAEA’s Programme ‘93+2’, Report VERTIC, January 1997. For a short description of problems during its negotiations see: A. Schaper, Detection of Non-Declared Activities Towards Nuclear Nonproliferation, Proceedings of the Workshop on Science and Modern Technology for Safeguards, Arona, Italy, 28-31 October, 1996, p. 341, Ispra 1997.

[61] M. Zifferero, IAEA Activities and Experience in Iraq under the Relevant Resolutiouns of the United Nations Security Council, Proceedings of the Symposium on International Nuclear Safeguards, Vienna, 14-18 March 1994, p. 211; D. Albright, R. Kelley, Has Iraq Come Clean at Last?, Bulletin of the Atomic Scientists, November/December 1995, p.53-64.

[62] IAEA, Implementation of the Agreement Between the Agency and the Democratic People's Republic of Korea for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (INFCIRC/403); M. Dembinski, Testfall Nordkorea – Die Wirksamkeit des verbesserten IAEO-Safeguardssystems, SWP-IP 2849, Juli 1994; K. Frank, Das Nordkoreanische Atomwaffenprogramm und das Nichtverbreitungsregime: Regimestabilität unter Streßbedingungen, Diplomarbeit im Fach Gesellschaftswissenschaften an der Johann Wolfgang Goethe-Universität, Mai 1996.

identified in the expanded declaration in order to gather specific information or to take environmental samples. The reforms go further by including enhanced safeguards training, improving the efficiency of the safeguards system, increased cooperation with national or regional systems of accounting and control such as Euratom.

The original proposal had met strong criticism mainly from NNWS with nuclear industries, notably Germany, Japan, Belgium, Switzerland, and Spain.[63] Several problems were in the center of the disputes on the draft. Among these 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 will become more difficult, and more specific solutions will have to be worked out, especially managed access similar to the verification foreseen in the Chemical Weapons Convention.[64] In addition, more intense control will inevitably result in more false alarms which might damage the reputation of the nuclear industry that has trouble to be accepted already; and the proposals do not only require the change of national law but could even affect the NPT because they seek to cover more than nuclear material. The latter claim is disputed among international analysts.[65] These objections give an idea of the complaints that may be expected from states without safeguards against the suggestion to accept them themselves.

The general objection maintains that the reforms will only be effective if they are implemented universally. An example is extended reporting of technology transfers. The analysis of acquisition activities would be incomplete as long as tracks are lost when goods touch a NWS. The lack of universality would also result in an injustice: the "good guys" would bear a much heavier burden. Even more than in NNWS, sensitive goods and knowledge can especially be found in NWS, e.g. Russia. Without universality, the variations of discrimination would increase: there would be NWS, NNWS who have adopted 93+2, NNWS who have not, and states outside the NPT.

The interests and intentions of those promoting the reforms, especially the U.S., was not to wide the gap of discrimination, but to help repair the damaged reputation of the IAEA and to appease critics of the nonproliferation regime. They would constitute a good example by the states where the reforms will be first implemented and thereby produce additional incentives and pressures for others to follow. However, discrimination on the other hand is not of concern to the NWS, and therefore a risk easily to be taken. All participants, including the SON, know that it is unlikely to have the same, very substantial reforms be applied everywhere at the same time. The conflict can be explained in the following way: the NWS want others, e.g. the NNWS, to be the ones doing the first steps while the NNWS’s first objective is to reduce perceived competitive disadvantages and inequalities.

The negotiations were finished in Spring 1997 and a final draft was presented.[66] Substantial concessions have been made, especially with respect to the intrusiveness and universality. The

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

[64] See A. Kelle, Das Chemiewaffen-Übereinkommen und seine Umsetzung – einführende Darstellung und Stand der Diskussion, HSFK-Report 12/1996.

[65] G. Bunn, Inspection for Clandestine Nuclear Activities: Does the Nuclear Non-Proliferation Treaty Provide Legal Authority for the International Atomic Energy Agency's Proposals for Reform?, OECD-Nuclear Energy Agency's Nuclear Law Bulletin, Vol. 57, June 1996.

[66] IAEA Press release: IAEA Board of Governors Approves Strengthened Measures to Verify Nuclear Weapons Pact, PR 97/9, 16 May 1997

final success will depend on the next steps which will be the implementation in the member states, e.g. specific agreements between the member states and the IAEA, also between Euratom and the IAEA.

2.4.4 Is there a trend towards safeguards also in nuclear weapon states?

All activities such as the international collaboration on disposition and improvement of the security of nuclear materials, the U.S.-Russian bargaining on transparency of each other's materials' storage, negotiations on plutonium management guidelines, the 93+2 negotiations, and the previous attempts to start cutoff negotiations, show a common pattern: all efforts aim at exerting more control over fissile materials and nuclear technologies. The original triggers of the various activities have different origins: an insecure nuclear weapon complex because of the break-up of the Soviet Union, suspicion of Japan because of its extensive civilian plutonium plans, dissatisfaction with the existing safeguards because of proliferation in Iraq and North Korea, frustration that there are still states outside the NPT, and the desire for nuclear disarmament, but the motivations and subjects of the activities have large overlaps and reflect the ever same interests and conflicts, stemming in particular from the desire to extend controls over other nations while minimizing one's own additional obligations. This applies equally to NWS, NNWS, and SON. All groups take the position that it is up to others to offer the next substantial step, but the principal need for more transparency and controls is hardly disputed. It is now widely understood that nuclear activities are not only national concerns. However, while this principle is self-evident tradition in NNWS, it is still new and undigested for the others.[67]

It is concluded here that the time is ripe. Although the current reality is the contrary of a consensus, the topic can hardly be removed from the agenda any more. An FMCT would put this complex of universal fissile material control reforms into 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 act as policy driver to ensure that verification measures are developed and applied in NWS.

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[67] The degree to which the NWS are ready to endorse IAEA safeguards for themselves varies. While the U.S. shows an increasing openness, it is unlikely that this idea is already seriously considered in Moscow: V. N. Misharin, a former diplomat who served two tours of duty at the IAEA said in an interview on IAEA Safeguards in the Former USSR: "The IAEA also should keep in mind that large segments of Russia's nuclear industry will remain outside IAEA control.", The Monitor, Vol. 1, No. 2, p. 4, Spring 1995. Amabassador Sha Zhukang presented China's position on verification as: "The verification measures should be least intrusive in nature and sufficient care been taken to avoid abuse" in a paper presented at the Workshop on "Fissile Material and Tritium – How to verify a comprehensive production cutoff and safeguard all stocks", Geneva, 29-30 June 1995.

3 The scope: What should be covered by a fissile material cutoff treaty?

Already during the negotiations on the mandate text, it became clear that there are many different ideas what the scope of an FMCT could be. The interest in disarmament and more universal controls will imply a preference for the inclusion of already existing materials, those interested in nonproliferation and the incorporation of all states will prefer a narrow scope which is restricted to only future production, because this seems more acceptable to the NWS and India.[68] In the first section of this chapter, some more details of the several technical categories, whose production could be banned or whose civilian use be verified will be presented. A categorization of materials is an interdisciplinary endeavour: it involves technical, legal, and political definitions and terms. The second part will give some scope variations, based on this categorization.

3.1 Classification of materials

3.1.1 Technical material categories and IAEA definitions[69]

At the center of technical proliferation concerns is *direct use material* that can be used for nuclear warheads without any further enrichment or reprocessing. That material is plutonium (Pu) and HEU.[70] The isotopic composition of Pu can vary depending on its technical origin. In NWS, *weapon grade Pu* is preferred for warheads, however, a crude nuclear explosive can also be fabricated from *reactor grade Pu*, as it occurs in all civilian programs that produce or use Pu.[71] Therefore, the IAEA does not make a legal distinction between them. Also MOX, as long as it has not been irradiated in a reactor falls into this category. HEU is defined as uranium whose U-235 component is enriched over 20 %. Typically, the enrichment of HEU used in nuclear warheads is much higher, above 90 %. Uranium used as fuel for civilian energy generation is only *low enriched* to about 3-5 % (LEU). It is not possible to make a warhead from LEU without further enrichment, in contrast to MOX, it is therefore not classified as direct use material. There are only three applications of HEU: nuclear explosives, naval fuel, and research reactors. Technically, it is possible to replace the HEU in naval and research reactors by lower enriched fuel, with only minor technical disadvantages.[72] Since direct use material has civilian

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[68] A set of measures aimed at strengthening fissile material controls has been analysed by: L. Gronlund, D. Wright, Beyond Safeguards – A Program for More Comprehensive Control of Weapon-Usable Fissile Material, Report by the Union of Concerned Scientists, May 1994. Several of these measures could also be elements of a cutoff scope.

[69] For a more detailed and comprehensive list of definitions see also Appendix II.

[70] The fissile isotopes are Pu-239, Pu-241, and U-235. There is also U-233, but so far no military application has become known.

[71] E. Kankeleit, C. Küppers, U. Imkeller, Bericht zur Waffentauglichkeit von Reaktorplutonium, Report IANUS-1/1989, this report has been translated by the Livermore Laboratory under the title "Report on the weapon usability of reactor-grade plutonium"; and C. Mark: Explosive Properties of Reactor-Grade Plutonium, Science & Global Security, Vol. 4, p.111, 1993.

[72] There have been considerable international efforts to convert research reactors to LEU fuel, with the long term goal to abolish this application completely and universally. Unfortunately, a new project of a research reactor to be fueled with HEU in Garching seems to undermine these attempts. See A. Schaper, Der ge-

and military applications, it has been proposed to ban the production of direct use material altogether.[73] This is certainly not acceptable for states with civilian Pu use and was also not the intention of Clinton when he made his proposal in 1993.[74] But a universal ban of HEU production in contrast could become a more realistic prospect. Only very small amounts are still used for civilian research reactors. The quantities used for naval propulsion are much larger, but for the foreseeable future this could be served with fuel from nuclear disarmament whose quantities are even larger. Some HEU fueled naval reactors could also be converted to LEU use.[75]

A broader category of materials is defined as all those that contain any fissile isotopes, it is called *special fissionable materials*. It includes direct use materials, and in addition also natural uranium (contains 0.7 % U-235), LEU, irradiated HEU, and spent fuel. HEU can be made from LEU by further enrichment, Pu can be obtained from spent fuel by reprocessing. In order to verify that no direct use materials are abused for military purposes, also special fissionable materials must be controlled. An even broader category is simply called *nuclear materials.* In addition to the special fissionable materials, it also contains so-called *source materials.* Source materials are those containing U-238 from which Pu is bred when irradiated in a nuclear reactor.

Another material whose production ban or control is also discussed in the framework of an FMCT is *tritium*.[76] Tritium in its nuclear applications undergoes not *fission* but *fusion*. In the IAEA classification, it does not count as nuclear material. It is used in modern warheads and in civilian fusion research. Since tritium decays with a half life of about 12 years, it must be replaced from time to time. As long as they still maintain arsenals, the NWS are therefore unlikely to accept a production ban. In nuclear warheads, it is used for a mechanism called "boosting": during the nuclear chain reaction, also fusion reactions between deuterium and tritium take place which release fast neutrons. These neutrons contribute to the chain reaction which therefore grows faster. As a result, a larger fraction of the fuel is fissioned, so that with boosting the energy release is larger while the quantity of fission fuel in the warhead stays the same.

There are also civilian applications of tritium, namely radioluminous colours for various applications, in nuclear physics, and in fusion research. The latter use will probably grow in future

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plante Forschungsreaktor in Garching – Rückfall in alte Sünderzeiten deutscher Nichtverbreitungspolitik? HSFK-Standpunkte Nr. 3, March 1996; H.-J. Didier, R. Bätz, Die Garchinger Hochflußneutronenquelle ist im Bau, Atomwirtschaft, Vol. 42, No. 3, p. 166, March 1997.

[73] Statement by Indonesia at the General Debate in the First Committee on Disarmament and International Security, New York, October 19, 1994; analysts who advocate such a total production ban are: B. G. Chow, R. H. Speier, G. S. Jones, The Proposed Fissile-Material Production Cutoff – Next Steps, RAND, National Defense Research Institute, 1995; W. Liebert, Proposal for a Comprehensive Cutoff Convention, Paper presented at the Workshop on "Fissile Material and Tritium – How to verify a comprehensive production cutoff and safeguard all stocks", Geneva, 29-30 June 1995; P. Leventhal, in: Nuclear Control Institute Press Release: U.S. Support for Total Test Ban Marks Historic Milestone – Total Ban on Bomb Materials is Crucial Next Step, August 11, 1995.

[74] Clinton in letter to Congressman Stark on Oct. 20, 1993: "I have not, however, called for a treaty banning all fissile material production. Such a proposal would breach existing U.S. commitments and lead to confrontation with Russia and our allies. This action would divert attention from cooperative efforts to stop proliferation, and undercut the impact of our fissile material initiative on countries currently outside the NP regime."

[75] Cf. section 4.5.1 Naval fuel.

[76] M. Kalinowski, L. Colschen, International Control of Tritium to Prevent its Horizontal Proliferation and to Foster Nuclear Disarmament, Science and Global Security, Vol. 5, No. 2, p. 130, 1994/95. See also section 4.5.2 Tritium.

because some large fusion experiments with tritium are planned in the next years. Most previous experiments so far have still worked without tritium.[77]

The following figure (Figure 1) is a "set-diagram" for an overview on all these technical categories.

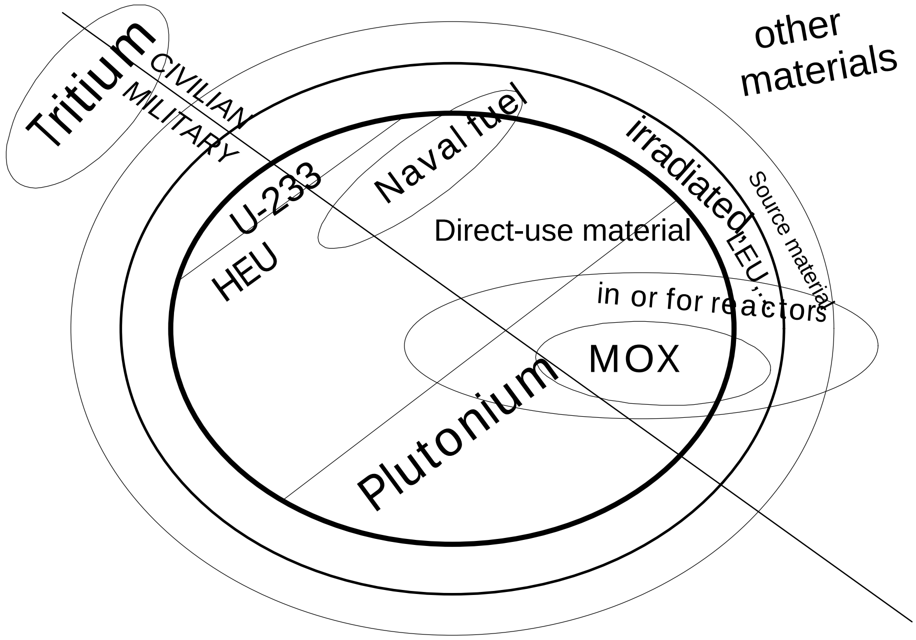

Figure 1: Overview on relations between different categories of materials

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[77] This applies especially to magnetic fusion. An international experiment facility will be ITER (International Thermonuclear Experimental Reactor, participation by Euratom, Japan, U.S., and Russia).

3.1.2 Utilization of plutonium and HEU

The following table (Table 1) gives an overview on quantities and production of military materials in several countries:[78]

State or region	*Pu inventory / t (31 Dec. 1994)*	*HEU inventory / t (31 Dec. 1994)*	*Pu production*	*HEU production*
FSU	131 ± 20%	1025 ± 30%	still producing, but interest to stop	stopped 1988
USA	85 ± 2%	645± 10%	stopped in 1988 legally permanent	stopped in 1964 since 1992
France	5.0± 30%	24± 20%	stopped 1992	stopped 1996
China	4.0 ± 50%	20 ± 25%	no official announcement, but believed	
UK	3.1 ± 20%	8 ± 25%	stopped 1995 [79]	stopped 1963
Israel	0.44	–	probably still occurring	–
India	0.30	–	probably still occurring	–
Pakistan	–	0.21	just started (Khushab reactor)	stop declared in 1991, but not trusted by India

Table 1: Inventories and production of military materials in several countries (tons)
Source: Albright, Berkhout, Walker[11]

It presents the most detailed numbers publicly known or estimated. The amount of material needed for one warhead is just a few kilograms.[80] The total amount of military materials is the cumulated production of the last decades, and the number of warheads that could be fabricated from it is higher than the nuclear arms race peaked during the Cold War. It is not surprising that especially the U.S. and Russia have stopped further production or intend to do so. In case only future production is banned but the amount of military materials is not irreversably reduced, a reversal of the nuclear arms race could still easily arrive at similar or higher warhead numbers.

Pu and HEU can be distinguished into the following categories of utilisation:

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 for transfer into the civilian use,

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[78] Inventories from: Albright, Berkhout, Walker, fn. 11, tables 14.3, 14.4, and 14.5.

[79] P. Marshall, BNFL halts military Pu production from Calder Hall Magnox Station, Nucl. Week, April 27, 1995, p.13.

[80] Cf. table in Appendix II: Euratom and other regional safeguards systems and their potential roles in a cut-off, p. 66.

5. military direct use material considered excess and declared for transfer into the civilian use,
6. direct use material currently in reactors or their logistics pipelines and storages, (naval and research reactors, power reactors, breeders),
7. irradiated Pu and HEU in spent fuel from reactors, or in vitrified form for final disposal

The military categories 1-5 are not regarded as illegal only in NWS and SON, as only the civilian categories 6 and 7 are allowed in NNWS parties to the NPT. Discussions of scope must focus on the questions concerning which of these categories will be banned, allowed, capped, reduced, declared and/or controlled, and to which extent. Table 2 gives an overview on Pu and HEU inside and outside operational nuclear weapons.[81]

	USA	*FSU*	*France*	*China*	*UK*	***average total***
Inside weapons						
Pu	28 – 37	38 ± uncertainty	1.5 – 2	?	1.5 ± uncertainty	**75**
HEU	140 – 280	165 – 330	7.4 – 14.8	9.0 – 13.5	3 – 6	**485**
Unknown destination						
Pu	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						
Pu	38.2	50 – 100 [a]	0	0	0	**74**
HEU	174.3	500 [b]	0	0	0	**674**
Under safeguards						
Pu	2 [c]	0	0	0	0	**2**
HEU	10 [c]	0	0	0	0	**10**
Total						
Pu	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**

Numbers for total, inside weapons, and U.S. declared excess from Albright/Berkhout/Walker (fn. 11).

[a] Not officially declared, but working figures used in disposition studies of Russian Pu, e.g. the Joint U.S./Russian study (fn. 47).

[b] Russia has agreed to sell 500 t weapon grade HEU to the USA over 20 years.

[c] from F. v. Hippel (fn. 50).

Table 2: Inventories of Pu and HEU inside and outside operational nuclear weapons (illustrative estimates).[11] The units are tons.

It can be seen from the table that there are large quantities of materials neither inside weapons nor declared excess, e.g. this "missing material" belongs into the above listed categories 2, 3, and 4. It is of the order of hundreds of tons, sufficient for tens of thousands of warheads. One reason why NWS are hesitating to put it under safeguards is that a large fraction is in the form of weapons components and must first be converted into a less proliferation relevant form.[82] However, opinions of what is considered too sensitive vary in a wide range. The scope of the

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[81] From Albright, Berkhout, Walker, fn. 11.

[82] Cf. section 4.5.3 Dual-use and military facilities.

cutoff will define a legal framework for its future, which as a minimum requirement must ensure that the total amount of military direct use materials can only be reduced, preferably, that at least categories 3 and 4 are abolished and category 2 is substantially reduced. In addition, the quantity of material in category 1 could be declared, which is a variant of the German proposal to implement a nuclear weapons register with the U.N.[83] The Indian demand for comprehensive disarmament is equivalent to a time bound framework for the ban of categories 1-5.

3.1.3 The current status of bans and safeguards on materials[84]

So far, there are no legal obligations for limitations, declarations, or international controls of any of the military categories beyond national legislations. Some civilian material in the NWS is subject to *voluntary safeguards*, some of which will be U.S. excess military material. But so far, much material is left out from any decision, whose future is not yet decided. All civilian nuclear material in France and the UK is subject to *Euratom safeguards*. But they have the right to withdraw it to defense needs, with the consequence that Euratom controls cease. If controls are not tightened, NWS could become a source of direct use nuclear materials, technologies and knowledge directly usable for nuclear weapons, and dual-use materials, technologies and knowledge for potential proliferators.

NNWS parties to the NPT are committed to accept safeguards on all nuclear material in all their peaceful nuclear activities (*full scope safeguards*). Full scope safeguards are also called INFCIRC/153-type safeguards according to the model agreement with the IAEA. The material of the EU members is additionally subject to Euratom safeguards, that of Brazil and Argentina subject to *ABACC safeguards* whose intrusiveness is comparable to that of Euratom. The group of NNWS may be subdivided into states with a good nonproliferation record that are unlikely to develop nuclear ambitions and those which might be tempted to start a nuclear program, e.g. North Korea, Iraq, or Iran. Additional countries that in future might fall in the latter category will in all likelihood be states that will have isolated themselves in the international community. The industrialized NNWS can be a source of dual-use materials, technologies and knowledge for potential proliferators.

India, Pakistan, and Israel are in possession of unsafeguarded military and civilian materials. They have some civilian facilities that are subject to *INFCIRC/66-type safeguards* which are restricted only to these facilities and do not cover all materials (also called *facility attached safeguards*). Similarly to the NWS, also this country group can be a source of direct use nuclear materials, technologies and knowledge directly usable for nuclear weapons, and dual-use materials, technologies and knowledge. In sum, there are voluntary, facility attached, and full scope IAEA safeguards, and full scope safeguards on civil materials by Euratom and ABACC, and in addition 93+2 measures. The following figure (Figure 2) depicts the several categories of materials that are possible, including the military categories listed above and the various legal safeguard categories for civilian materials.

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[83] K. Kinkel, "German 10-point initiative for nuclear nonproliferation", Bonn, 15 December 1993. For the significance of this proposal and the reaction of the NWS see: H. Müller, Transparency in Nuclear Arms: Toward a Nuclear Weapon Register, Arms Control Today, October 1994, p.3.

[84] The legal properties of current safeguards are explained in detail in section 4: Verification.

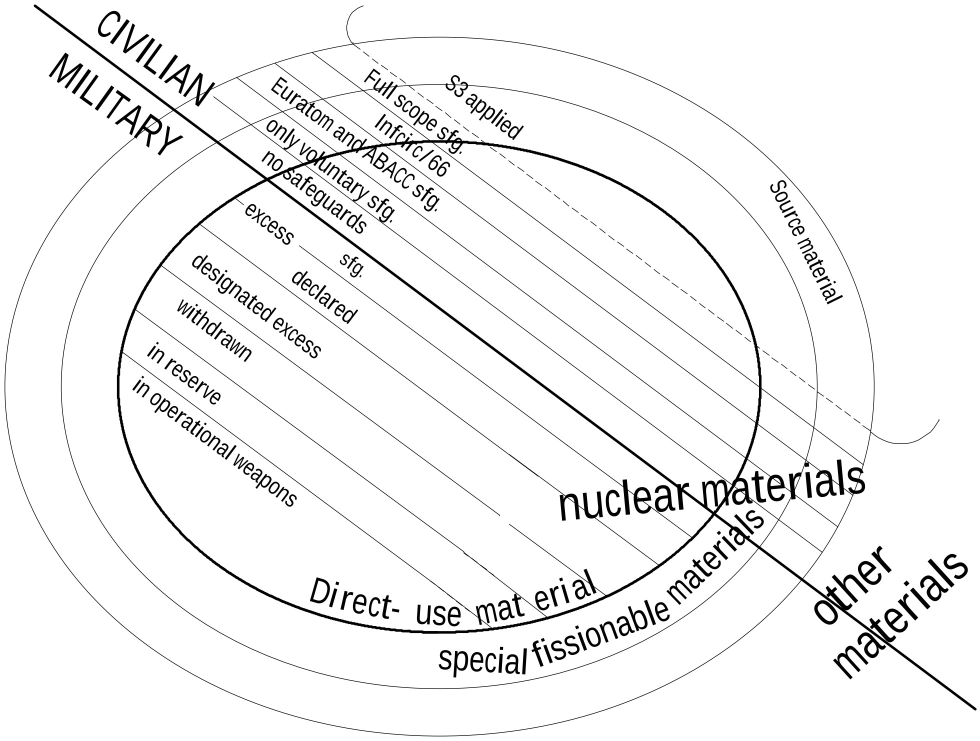

Figure 2: Overview on different categories of civilian and military nuclear materials

The next figure (Figure 3) adds to this depiction several countries and country categories.

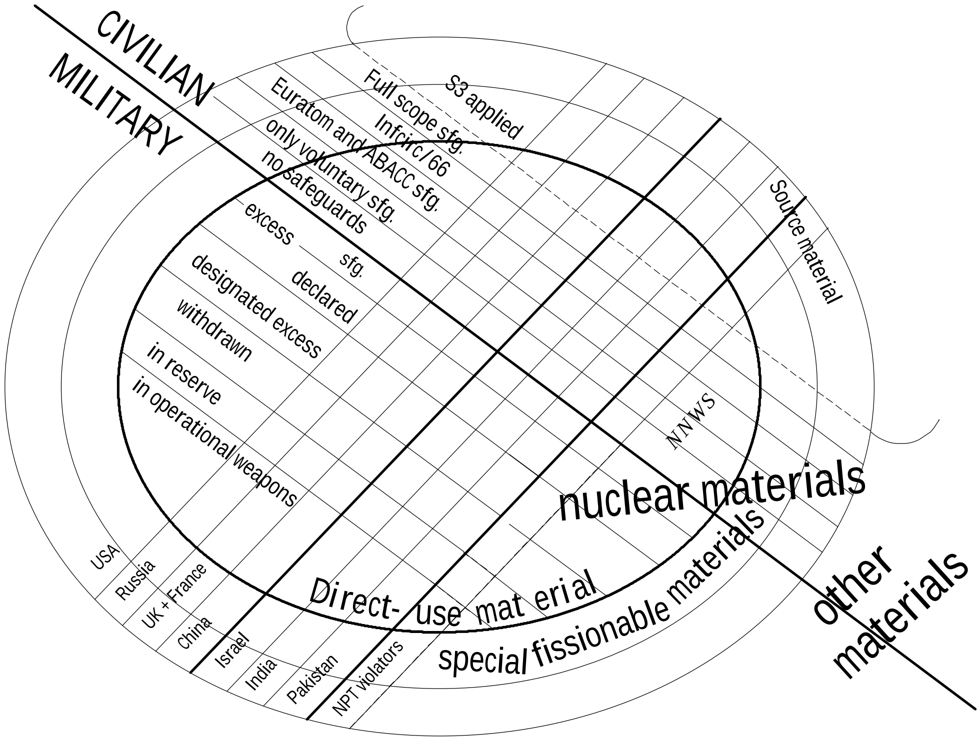

Figure 3: Overview on material and country categories

Not all theoretical combinations of countries, country categories and legal statuses of material categories exist. In addition, the 93+2 reforms will be implemented earlier in some states, and later in others. As a summary, the following depiction (Figure 4) illustrates the situation of *today*: combinations that do not exist, e.g. Russian material from disarmament under safeguards, or combinations that are banned, e.g. unsafeguarded materials in NNWS, are shaded: ░ , existing combinations are left in white color, in case this is not known, they are hatched. This situation is in transition because of the implementation of 93+2 (part II). The figure presents a snapshot since declared excess materials can also already be categorized as civilian materials, e.g. the line between civilian and military materials is moving. This move becomes politically stabilized when excess materials are declared, and it becomes more irreversible when confirmed by international law.[85] So far, all NWS (and SON) can move all lines between the several categories as they please, with the exception that France and Britain are not allowed unsafeguarded civilian materials, however they can transfer it to unsafeguarded military categories.

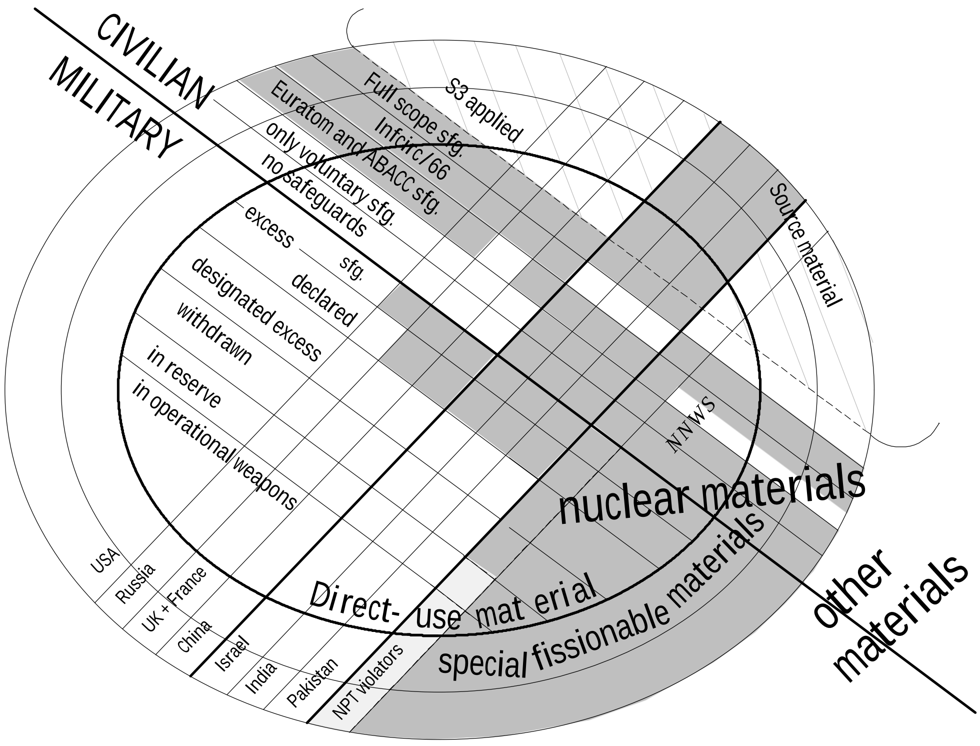

Figure 4: Overview on today's existing and not existing combinations of country categories and categories of legal statuses of materials

3.2 Some variations of scope with different degrees of obligations

3.2.1 The original approach: ban only on future production

A ban just on future production without measures on existing materials was the original U.S. proposal. It would cement what is already almost reality. It fits with the first priority of inter-

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[85] A 100 % technical irreversability is not possible, however can be approached by various disposition methods. See section 2.4.1.

ests of the NWS which is nonproliferation, e.g. getting all others including all NWS and SON into a treaty, while at the same time keeping own additional obligations as low as possible. As long as no other measures on existing materials are taken, the major benefit would be inserting some controls into the three SON, in case they can be persuaded to participate. A second advantage would be the good prospect for broad acceptance in NWS. The third advantage would be the formal fulfilment of an important requirement of the Principles and Objectives, which would be helpful for the success of future NPT review conferences. A fourth advantage in the view of the NWS would be that they can point to the achievement of an FMCT as another nuclear disarmament success.

But there are also disadvantages: the NWS would retain a reservoir of military direct use materials for rearmament, which would be huge for the U.S. and Russia. The cap would only take effect when an eventual rearmament would go far beyond of what were the highest warhead numbers during the Cold War. Secondly, most of this material would not even be declared, let alone be safeguarded. Thirdly, this would not only weaken the disarmament component, but also weaken the nonproliferation goal because without controls on materials, transfers cannot be controlled internationally either. Fourthly, the claim that the FMCT constitutes a major disarmament measure could be denounced as hypocritical, because these flaws are widely seen, and the assumption that the presentation of an FMCT will smooth future review conferences could turn out in its contrary. Finally, an important disarmament symbol would have been wasted by missing the opportunity to giving it more substance.

In case just future production is banned and only enrichment and reprocessing plants are monitored, the picture of Figure is the same, it might only be changed by accession of SON. All lines between NWS’s categories could still be moved freely, only the mechanism of enlarging the total amount of military materials would be banned, but even this only if it is forbidden to transfer civilian material into military categories. This scenario serves the interests of getting the SON in and of giving them some legitimation, but it runs counter the interests of disarmament and globalization of controls.

3.2.2 The good-will-approach: strive for reductions of the amount of military material

A more far reaching proposal for the scope would in addition to the original approach include the following:

a) the ban of future production,

b) the ban to transfer material back to military uses, once it has become civilian,

c) the register of upper limits that are allowed for undeclared material, e.g. material above this limit must be declared excess, e.g. it must be put into category 5 of the above list (p.21). A variant or complement could be an International Nuclear Weapons Register.[83]

Also this approach has advantages and disadvantages: one advantage would be that the amount of military material can legally only be reduced but not enlarged. For those SON interested in legitimation, it serves their interest since it specifies some material categories and allows keeping unsafeguarded stocks. In other words, everybody is allowed to possess a *black box* of unsafeguarded material, with the black box of NNWS being already empty. Other advantages are the same as in the "original approach" of section 3.2.1. The categorization picture of Figure would look more simple because of less categories, and the lines between categories could not be moved freely any more.

But there are also disadvantages: The major disadvantage is that the NWS and SON can still keep stocks as large as they please though being under some political pressure to justify the need for military purposes. Legally, they can classifiy as much as they like as "necessary for maintaining the stockpile" without even revealing numbers. A major disadvantage is that the declarations of upper limits are only declared but not controlled, and a break-out would be still relatively easy. The interests of those who want more security and control discipline of nuclear materials are not served.

3.2.3 The one-way-approach: make sure the amount of military material is not increased

The scope would be more convincing if there were more obstacles against a reversal. This could be accomplished by the following additional obligations:

d) the ban to withdraw material from international safeguarding. This goes beyond what is currently legal under the voluntary safeguards agreements with the IAEA which allow the withdrawal of materials from safeguarding "in exceptional circumstances".[86]

e) the obligation to put declared excess material (category 5) under international safeguards within a defined timetable.[87] The definition of the timetable should be more explicit than the wording of the Moscow P8 nuclear summit declaration "as soon as it is practicable to do so" (cf. section 2.4.1). A timetable will probably be necessary because there might be specific problems at former military sites that must first be solved (cf. section 4.5.3.).

The advantage would be that the control over fissile materials would be steadily increased and would thereby better serve disarmament and nonproliferation. Also related activities would be confirmed and strengthened, especially the already ongoing efforts to submit Russian and U.S. declared excess materials under IAEA safeguards.

3.2.4 The disarmament approach: built-in mechanisms for reduction

Instead of building in only some political pressure not to keep military stocks too large, some more binding disarmament obligations would be created when the scope would also cover the following item:

f) the obligation to adjust the upper limits of undeclared material to future nuclear disarmament treaties, e.g. a START-III treaty and others that might come. This implies that these limits must be justified in negotiations on their quantities and made plausible with rough estimates of how much is averagely needed for one warhead, as soon as the next nuclear reduction treaty is concluded.[88] This will create pressure to keep them low. As a consequence, the limits will not be much larger than the actual need, e.g. in weapons and in reserve for military purposes (categories 1 and 2). Large ambiguous stocks considered excess but not declared so (categories 3 and 4) will be delegitimized as a consequence. Those who do not yet have any such treaty start with arbitrary numbers or numbers to be negotiated. The U.S. and Russia start with numbers and a time frame that fit to START-II (or III), the NNWS start with zero.

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[86] T. Shea, On the Application of IAEA Safeguards to Plutonium and Highly Enriched Uranium from Military Inventories, Science & Global Security, Vol. 3, p. 223, 1993; B. Pellaud, fn. 53.

[87] This corresponds to the proposal of an International Register of Plutonium and HEU: D. Albright, F. Berkhout, W. Walker, World inventoy of plutonium and highly enriched uranium 1992, SIPRI, Oxford University Press, 1993.

[88] As an example, the U.S. National Academy of Sciences has a "working figure" of 4 kg plutonium per warhead for its disposition studies (fn. 38). This does not mean that this is the real number. The tables in Appendix III give an impression on the variations of these numbers.

Again, there are advantages and disadvantages: the major advantage is that most of the military material will after some time be irreversibly transferred into civilian categories, thereby constituting true nuclear disarmament. The military quantities would be far less than in the original or one-way approaches. Secondly, official numbers would underline the commitment for international and universal bookkeeping and the international responsibility for disarmament. Thirdly, a balance sheet, especially with an implicit time table towards reductions, created by the NWS and SON themselves is a necessary step towards nuclear disarmament and would enhance the credibility of the commitments of Article VI of the NPT and of the Principles and Objectives. Finally, official policies of the participants would not be violated: the U.S. and Russia pursue as they have planned and undertaken anyway, e.g. with storage and disposition plans and START 3 negotiations, the UK, France, and China can maintain their current policies of joining nuclear disarmament only when that of the U.S. and Russia has become more substantial, India would get a face-saving compromise because some equivalents of time tables will be built in, e.g. for putting excess materials under safeguards or for links with other disarmament treaties, Pakistan will join when India joins, and Israel can keep up its policy of neither confirming nor denying the existence of nuclear weapons, since the registered numbers are fictitious for a start and not understood to be reflecting the real amount of military materials still in use.

The major disadvantage, however, is that the declaration and registration of different upper limits ranging from more than hundred tons down to zero may constitute an incentive for disagreements and conflicts. Participants in negotiations may raise the argument of discrimination; an official number, for example, different from zero for Israel, though fictitious, still has the potential to create anger in the Arab world. Pakistan might object in case numbers for India are higher, and some NNWS might object to numbers different from zero for some SON. Certainly, this would pose a challenge for the negotiation skills of diplomats. Secondly, such strong commitments simply are disliked by most NWS who still try to keep their national actions as independent and opaque as possible. The most open NWS is the U.S. They certainly are also disinterested in the implicit strong international pressure that will be created by such an FMCT scope.

This approach has the potential of getting the SON in as well as putting disarmament obligations on the NWS and could therefore serve all interests. It also means that everybody has to pay a higher price.

3.2.5 The Indian approach: a time-bound framework for comprehensive nuclear disarmament

As a condition for its cooperation, India now asks for nothing less but a timetable for comprehensive nuclear disarmament. In the logic of the above list of scope elements, another element would be added:

g) The obligation to reduce all military material in a defined time down to zero.

This has been unacceptable for the NWS and presumably also for Israel during the CTBT negotiations and is equally now. This demand is the reason for the current deadlock in the CD. In fact, an FMCT has always been understood as a step towards nuclear disarmament and as a disarmament symbol, but not as the final nuclear disarmament treaty. Time-bound proposals are always problematic where substantial problems have to be solved. They neglect the obstacles and problems that have hitherto resisted nuclear disarmament. Proponents of timetables for nuclear disarmament refuse to first approach solutions for these problems.[89]

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[89] W. Walker, Evolutionary versus Planned Approaches to Nuclear Disarmament, Disarmament Diplomacy, p. 2, May 1997; H. Müller, Far Reaching Nuclear Disarmament, in UNIDIR Newsletter, Nr. 31/1995, S. 31-38 (French version: "Désarmement nucléaire: la signification du "zéro arme nucléaire", ibid. p. 17-26), ISN 1012-4943.

4 Verification

4.1 The logical implications of the principle of "nondiscrimination"

As there are many variations of scope, also many verification scenarios are possible, reaching from just a fence around former military production facilities to complete new global concepts. In case the scope is only the original approach, e.g. only a ban on future production, it still has to be ensured that material produced later is not simply declared as earlier production. The consequence is that all civilian and military materials being produced after entry into force must be put under safeguards. If the civilian material would be left out, it could later be declared as earlier production and diverted into military use. Even in case of an FMCT with the most limited scope (only item *a)* of the above list, even not item *b)*), verification must cover not only nonproduction but also nondiversion at least of civilian materials produced later. This is the same as what is already being verified in NNWS under full scope safeguards, with the only exception that NNWS are not allowed the possession of unsafeguarded materials from earlier production. In other words, no material must be diverted to nuclear weapon use, equally for all members of a *nondiscriminatory* FMCT, except that the NWS and SON are allowed a "black box".

The next question is: what is a satisfactory verification that ensures with high enough confidence that this obligation is met? The similar obligation of not diverting nuclear materials for weapon purposes is being verified by the IAEA in NNWS, literally it is defined as: "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purpose unknown, and deterrence of such diversion by the risk of early detection." The agreements between the IAEA and the inspected state are based on a model agreement, called INFCIRC/153.[90] It sets the principal requirements for *full-scope safeguards*. They do not only cover direct use materials and their major production facilities which are reprocessing and enrichment plants, but also the next category, special fissionable materials which also include LEU and spent fuel. Even source material is controlled, though to a less intrusive extent. Full scope safeguards are therefore being applied in all nuclear facilities, including normal power reactors. After the experiences in Iraq, even this has been found unsatisfactory, so that the 93+2 reform has started with even more intrusive controls, which have the additional goal of detecting undeclared production and even preparations for production, by methods including collecting environmental samples to be investigated for their content of suspicious isotopes. The principle of universality is an important prerequisite for the success of the reform. Consequently, the logical conclusion can be drawn that a similar verification system would also be appropriate and necessary for an effective FMCT verification.

The question arises why different standards for the NPT or for the FMCT should be set, although the verification task is the same. Why should a lower standard in the one case be satisfactory while it is not in the other? It can be argued that as long as a NWS has not disarmed

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[90] EU members have transferred the souvereignty of owning civilian nuclear materials including accountancy authority to Euratom. In this case, there is a safeguards agreement between Euratom and the IAEA (INFCIRC/193). For a description of IAEA safeguards see: D. A. V. Fischer, The International Atomic Energy Agency and Nuclear Safeguards, in: D. Howlett, J. Simpson (Ed.), Nuclear Non-Proliferation – A reference handbook, Longman, Harlow, 1992.

down to zero, some warheads more or less do not make much difference, and secondly, as long as a NWS's black box of unsafeguarded materials is not empty, it makes less a difference if small diversions remain undetected. However, the goal of verification is the deterrence of noncompliance by creating a sufficiently high detection risk. Even in NNWS, there will always remain a low probablity that noncompliance remains undetected, and this probability is determined by a balance between trust and technical verification efforts and costs. The higher the trust, the lower is the detection probability that still can be tolerated. For the NPT, the trust into the NNWS is not high enough to renounce full scope safeguards or to lower standards. The question must therefore be posed differently: why should NWS be more trusted not to divert fissile materials for nuclear explosive purposes than NNWS? A provocative variant of this question is: who can be more trusted, those who have renounced nuclear weapons, or those who still maintain nuclear arsenals and huge quantities of unsafeguarded weapon materials? At stake is not just a question of technical feasibility but more principally, the question of the importance of treaty compliance. It would be discriminatory if there were two different classes of state parties who are granted two different degrees of trust.

But the current reality is that the NP regime is discriminatory, and that the reduction of discrimation can only be achieved in steps but not as a whole. So far, full scope safeguards are still difficult to accept for NWS. The reasons are, firstly, the conservative inertia that still drives decision makers towards viewing nuclear policies as exclusively national matters. Accepting full scope safeguards is a severe cut of national souvereignty. Secondly, installing a verification system is indeed a technical challenge.[91] Most production plants in NWS, especially in the early years, have never been designed for safeguards, also bookkeeping never had the same priority as in NNWS, because there never was the need for international justification. Technically, it is much more difficult to implement them afterwards than to implement them already while the facility is designed and constructed. Therefore, it is not surprising that many analysts from NWS envisage far less verification for a start and suggest a step-by-step approach.[92] The only case in history when a state possessing nuclear weapons converted to a NNWS and implemented comprehensive safeguards is South Africa. The safeguards implementation was a success, but also revealed new technical challenges differently to those known from previous safeguarding.[93] Britain brought a large reprocessing plant (B205) under Euratom safeguards some 20 years after it was designed. Although the safeguards applied there might not meet IAEA criteria, Euratom is satisfied that it can verify non-diversion from the plant. It would be worth a study how the UK brought B205 under safeguards.[94]

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[91] On the technical abilities of the IAEA to verify a cutoff see: P. Hamel, Verifying a Cut-Off in the Production of Fissile Material: Considerations, Requirements, and IAEA Capabilities, Paper presented at the Geneva Workshop, 29/30 June 1995.

[92] E.g., Berkhout, Bukharin, Feiveson, and Miller: "The burden of a comprehensive verification system might be mitigated if the intensity of safeguards in the declared NWS were relaxed somewhat from that applied in the NNWS", fn. 11, p. 183; von Hippel and Fetter, fn. 13; Zhu Qiangguo, A Cutoff of Fissile Material Production for Nuclear Weapon Purposes and Its Concerned Issues, Paper presented at the 8th International Summer Symposium on Science and World Affairs, Beijing, China, July 23-31, 1996; Jin Hiumin maintains that the objective of an FMCT is just the shut down of military facilities, so that verification of civilian activities has not much to do with it, see fn. 3.

[93] S. Fetter, Verifying Nuclear Disarmament, Stimson Center, Occasional Paper No. 29, October 1996.

[94] Communication with W. Walker.

4.2 The nuclear fuel cycle and existing safeguards

IAEA safeguards are a verification system within nuclear nonproliferation policy, the NPT, and the Tlatelolco Treaty to ensure that no nuclear material is diverted to use for nuclear weapons or other nuclear explosive devices. A state aiming at clandestine acquisition of direct-use material has several options for procurement strategies:[95]

1. it can reuse already shut-down facilities,
2. it can pursue additional undeclared operations in operating declared facilities,
3. it can divert Pu or HEU from declared inventories,
4. or it can use clandestine undeclared production facilities.

Safeguards must be designed in a way that they are capable of detecting any of these operations with a sufficient probability. Before the 93+2 reform, the basic objective of INFCIRC/153-type safeguards, e.g. those verifying the compliance of NNWS with the NPT, aimed mainly at detecting diversion, e.g. the third strategy. The safeguards objective is stated as:

> "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or for other nuclear explosive devices or for purposes unknown."[96]

For HEU production, feed material, e.g. natural, depleted or low enriched uranium, and an enrichment facility are necessary. For Pu production, the requirements are spent fuel and reprocessing technology. Therefore, the most proliferation relevant elements of the nuclear fuel cycle are enrichment and reprocessing. However, safeguarding only them would leave too many loopholes, and therefore INFCIRC/153-type safeguards do not only cover direct Pu and HEU production facilities but also all other elements of the whole nuclear fuel cycle and nuclear reactors without exception, the respective intrusiveness depending on the technical hurdles to acquire direct use material. INFCIRC/66-type safeguards were designed in contrast mainly to apply to individual shipments of plants and materials to SON. In practice of a single facility, both often consist in similar control measures, however, large loopholes remain as long as the underlying approach does not systematically cover the entire fuel cycle. Safeguards agreements between NWS and the IAEA also apply only to individual facilities, and additionally, for NWS there is always the legal possibility to withdraw a facility from controls. The number of facilities in NWS currently submitted to voluntary IAEA safeguards is small for three reasons: firstly because of limited funds, secondly because not much sense had been seen in verifying nondiversion in states that are legally allowed to produce undeclared and military nuclear materials, and thirdly because in these states, the assumption is still prevailing that their nuclear production is only a matter of national but not of international concern.

INFCIRC/153-type IAEA safeguards require the establishment and maintenance of a State’s system of accounting for and control of nuclear material (SSAC), whose correctness is verified by the IAEA. It is a legal function of a national authority, based on technical material control and accountancy measures (MC&A). INFCIRC/66-type IAEA safeguards do not explicitly call for states to establish an SSAC, but require a "system of records" and a "system of reports" which practically implies the need of a system similar to an SSAC. In sum, nonproliferation and security of fissile materials and installations are controlled in several steps: the first step are national physical protection measures, the second are technical MC&A measures at the indi-

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[95] T. E. Shea, Verifying a Fissile Material Production Cut-Off: Safeguarding Reprocessing and Enrichment Plants: Current and Future Practices, Seminar on Safeguards and Non-Proliferation, IAEA Headquarters, November 16-17, 1995.

vidual facilities, the third is the SSAC run by the state (or in case of the EU by Euratom)[97], and the fourth is the additional verification by the IAEA. However, the facilities placed on voluntary offer lists by NWS must be capable of meeting IAEA safeguards criteria. Their operators must therefore follow IAEA accounting rules and procedures.

After the experience with Iraq's proliferation, the safeguards objective of only detecting diversion of fissile materials has been found unsatisfactory which has led to more emphasis on the additional goal of detecting clandestine acquisition activities, e.g. also early detection of the other procurement strategies in the above list. This has resulted in the 93+2 reform (cf. chapter 2.4.3). Now, not only nuclear materials but also non-nuclear elements of the nuclear fuel cycle and research and development are affected by control or reporting measures. They also do not only aim at the receiving end but also at the supplying end of a technology transfer chain. The supplying end in case of proliferation are especially states with nuclear industry, including NWS, NNWS, and SON. The following table (Table 3) gives an overview on the most important fuel cycle elements, their significance for the acquisition of direct use material, and the current status of IAEA safeguards.[98]

Apart from IAEA safeguards, there are also regional safeguards systems, namely Euratom and ABACC. For a couple of years, rising interest in a regional safeguards system in parts of Asia, already named "*Asiatom*", can be observed. Similar to the verification of the NPT, also the verification of an FMCT could be facilitated and even catalyzed by regional systems.[99]

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[96] § 28 of INFCIRC/153 (Corrected), June 1972. For explanations of the terms *timely detection*, *significant quantities*, *detection probability*, and *false alarm probability* see Appendix III. Source: IAEA Safeguards Glossary, 1987 Edition.

[97] Often both 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.

[98] IAEA, INFCIRC/153 (Corrected), June 1972; Model Protocol Additional to Existing Safeguards Agreements Between States and the International Atomic Energy Agency (Unofficial electronic version), http://www.iaea.or.at/worldatom/inforesource/pressrelease/protoindex.html.

[99] For more details, see Appendix II: Euratom and other regional safeguards systems and their potential roles in a cutoff

Type of facility, activity	**Potential roles for nuclear weapons acquisition**	**IAEA Safeguards**
Open fuel cycle (= final disposal of spent fuel)		
U mining and ore processing	Results in uranium concentrates, *first step* leading to fuel or HEU production; U ore can be found in many sites all over the world	INFCIRC/153: none, exports and imports reported (§ 33) 93+2: General reports to the IAEA
U refining and conversion	Purification, conversion into UF6 as feed material for enrichment *(second step)*	INFCIRC/153: safeguards start, when the process is finished (§ 34) 93+2: General reports to the IAEA
U enrichment	Potential for *fabrication of HEU* from less enriched U, but mostly used for fabrication of LEU for reactors	HEU (= special fissionable material) possible Infcirc/153: The extent of safeguards, e.g. the actual number, intensity, duration, timing and mode of routine inspections and other measures depend on the inventory, chemical and isotopic composition and annual throughput of nuclear material. Infcirc/66 type safeguards can be similarly attached, but are restricted to individual facilities, not the entire fuel cycle. 93+2: enhanced reporting, environmental samples, complementary access, managed access ...
Reconversion	Chemical process to fabricate ceramic U-Oxide from UF_6 , *diversion risks*	
Fuel fabrication	Fuel elements from U-Oxide for nuclear reactors, many variations, some containing HEU (or U-233, which is rare), *diversion risks*	
Irradiation in nuclear reactors	Produces spent fuel containing: rests of unfissioned *U, Pu,* fission products; risk of *additional undeclared production and diversion* In fast breeders, *weapon grade Pu* production	
At-reactor spent fuel storage	*Diversion risks*	
Away-from-reactor spent fuel storage	*Diversion risks*	
Conditioning of spent fuel	After about 50 years cooling, e.g. decay of many fission products, preparation for final disposal, *diversion risks higher* because of lower radioactivity	
Final disposal of spent fuel	At present, no operating final repository, but several under study. *Diversion risks* would be much *smaller*.	INFCIRC/153: safeguards cease when the material is practicably irrecoverable (§ 11, 35) 93+2: provision of information
Heavy water production	Heavy water reactors can be fueled with natural U, thereby rendering unnecessary the enrichment technology for the production of spent fuel (for *Pu acquisition*) which otherwise would be a prerequisite.	INFCIRC/153: none 93+2: provide the Agency with information
Other: R&D, equipment, …	Research and development, technical components and plants without nuclear material, locations outside facilities, closed down or decommissioned facilities *Potential preparation for acquisition*	INFCIRC/153: none 93+2: provide the Agency with information or make any reasonable effort to do so
Additional elements in a closed nuclear fuel cycle (= also reprocessing and recycling of Pu)		
Spent fuel reprocessing	Alternative to final disposal: separate the Pu and unfissioned U from spent fuel (by chemical methods in combination with radiation protection technologies). Results in separated *Pu = direct use material. Diversion risks*	special fissionable material: Pu, MOX. Addionally possible: HEU INFCIRC/153: More intrusive than in case of lacking special fissionable material. The extent depends on the inventory and annual throughput. INFCIRC/66 type safeguards can be similarly attached, but would be restricted to individual facilities, not the entire fuel cycle. 93+2: enhanced reporting, environmental samples, complementary access, managed access ...
MOX fuel fabrication	Fuel in which some of the fissile U-235 in U is replaced by fissile Pu. As long as not irradiated, this counts as direct-use material. Contents depending on reactor type. *Diversion risks*	

Table 3: Overview on the most important nuclear fuel cycle elements, their proliferation relevance, and IAEA safeguards

4.3 Control and detection of direct use material production

Although IAEA, Euratom, and ABACC safeguards cover the whole nuclear fuel cycle, and although a strong case is made in this report to do the same in the FMCT verification, a closer look specifically at the production of direct use materials is useful: in all likelihood the NWS will start the negotiations with the position to limit the verification only to direct use material production. This will therefore play an especially prominent role in the technical aspects of negotiations, and it may be helpful for the readers of this report if this subject is covered in some more detail.

Methods of safeguards depend on the task, they include seals, monitors, surveillance of special activities, analysis of samples, design verification, independent measurements of inventories, various material accountancy measures, ad-hoc-, routine-, and special inspections, environmental sampling, remote monitoring, and inspector deployment. The IAEA sees itself as the appropriate agency for the verification of an FMCT.[100]

The specific technological requirements of verification depend on the characteristics of the technical production process. HEU is being produced in enrichment, and Pu in reprocessing plants. Both have a lot in common but also some specific differences:[101] Both process nuclear materials flowing through a succession of stages involving many vessels and piping, therefore the diversion could take place at many locations. Verification must be able to detect any of them. Both processes also leak out characteristic traces of nuclear isotopes which can be detected. Verification that a declared shut-down facility remains so or detection of clandestine activities make use of this fact.[102] Differences will be explained in the following.

4.3.1 Highly enriched uranium and enrichment

For HEU production, feed material, e.g. natural, depleted or low enriched uranium, and an enrichment facility are necessary. Uranium enrichment technology separates between the isotopes U-235 and U-238 whose slightly different masses result in slightly different behaviors in various physical mechanisms.[103] Any of these mechanisms can in principle be made use of in a separation plant for both LEU and HEU production. The most common technologies are *gaseous diffusion*, whose mechanism is exploiting the small different permeabilities through porous barriers, and *centrifuges* that exploit the slightly different centrifugal forces that result from acceleration. The former is the most common method in the U.S., the latter in Europe. *Aerodynamic enrichment*, e.g. the *jet nozzle* and *helicon* processes that had been used by South Africa utilizes the fact that streaming properties show small variations. Iraq had used *electromagnetic separation* that makes use of the somewhat different acceleration by electromagnetic forces (EMIS). *Chemical isotope separation* exploits slightly different chemical reaction equilibra but so far has not come above pilot plants in France and Japan. A new enrich-

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[100] This is also the expectation of the IAEA. See S. Thorstensen, Fissile Material and Verification – IAEA Capability and Infrastructure for Verification of Fissile Material, Presentation at the Cut-Off Convention Workshop, Toronto, Canada, 17-18 January 1995.

[101] T. Shea, fn. 95.

[102] Cf. list of options for procurement strategies on page 32.

[103] A comprehensive overview on enrichment technologies and their significance for proliferation is: A. S. Krass, P. Poskma, B. Elzen, W. A. Smit, Uranium Enrichment and Nuclear Weapon Proliferation, SIPRI, Taylor & Francis Ltd, London and New York, 1983; see also Albright et al., fn. 11, Chapter 2.

ment technology expected to be applied commercially in a few years is *atomic vapor laser isotope separation* (AVLIS), its underlying physical mechanism is based on slightly different physical behavior of the electron shells of different isotopes.[104] A test facility is being run in the USA (U.S. Enrichment Corporation)[105], France's efforts are still in the development stage, the demonstration of the technical feasibility is expected in 1997 (Commissariat a l'Energie Atomique together with Cogema).[106] In South Africa, research and development of a similar technology, *molecular isotope separation* (MLIS) is underway, in cooperation with the French company Cogema.[107] In contrast to AVLIS, MLIS makes use of UF_6. Another technical variation is *chemical reaction by selective laser activation*.

Most plants are built in cascades of many subsequent enrichment units running parallel and in sequence. Each single separation unit only enriches the uranium by a small step, and many stages are needed to reach high levels. About 1000 sequential stages are needed for LEU production in a diffusion plant, about three times as many for HEU production. For a centrifuge plant, these numbers are about 20 and 60, respectively. Chemical separation needs several 1000 stages. A reconfiguration of the elements is a major technical effort that in safeguarded facilities does not remain undetected. AVLIS, in contrast, has a very large single stage separation factor, which means that it will become easier to convert LEU to HEU production.

The basic safeguards approach is material accountancy that verifies the report of the SSAC, supplemented by containment and surveillance techniques. The analysis of samples of the various material streams is another routine safeguards measure in enrichment plants. For this purpose, measuring equipment is installed at various points to control the isotopic composition of the streams. In plants not designed to be subject to safeguards from the beginning, as are former military production plants and other civilian plants in NWS and in the SON, such installations must be added in the aftermath**.** 93+2 has additionally implemented the option of taking environmental samples to ensure that no additional undeclared HEU production has taken place. However, this method works only in LEU facilities where no previous HEU production has ever taken place. It would cause false alarms in former military facilities that have been converted to LEU production.

The operation of an enrichment plant releases several characteristic signals which can be used for the detection of undeclared HEU production:[108] For diffusion, centrifuge, and aerodynamic processes, the uranium must be converted into uranium hexafluoride (UF_6) that reacts with water and air and therefore diffuses into the environment where it can be detected and even its enrichment level be analysed. No other industrial process makes use of UF_6. Chemical separation also has effluents of U-compounds. Electromagnetic separation and diffusion enrichment plants radiate large amounts of heat that can be detected by infrared measurement equipment outside, on satellites or on aeroplanes. Centrifuge plants need a lot of electric power whose lines can be detected unless the supply is built underground, and in addition generate characteristic high frequency electromagnetic signals which leak out into the vicinity and into the

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[104] See Krass et al, fn. 103 and R. Kokoski, Laser isotope separation: technological developments and political implications, SIPRI Yearbook 1990, p. 587, Oxford 1990.

[105] W. Dizard III, AVLIS test runs over a week; NRC takes over GDP regulation, Nuclear Fuel, March 10, 1997.

[106] A. MacLachlan, France 'on schedule' to show feasibility of SILVA in 1997, Nuclear Fuel, March 11, 1996.

[107] A. MacLachlan, Cogema to help South Africa's AEC develop MLIS enrichment process, Nuclear Fuel, March 11, 1996.

[108] See also: U.S. Congress, Office of Technology Assessment, Environmental Monitoring for Nuclear Safeguards, OTA-BP-ISS-168, September 1995.

electric system. However, all this applies only in the operation stage of a plant. The detection probability of construction is much lower than that of operation, however, import activities of components by less developed states can be an indication. In industrialized states, such components are produced indigenously, so this detection method does not work. Principally, an undeclared plant could be clandestinely built underground or in tunnels, which would also require a shielded cooling for removing the telltale heat, and strong shielding to limit the leakage of telltale radioactive particles or other signals. This cheating method would require a tremendous technical effort and the construction activities can be observed by satellites.

AVLIS, in contrast to other enrichment methods, has a much lower energy consumption which would make the detection of a hidden plant much more difficult. Also, it uses uranium in the atomic state and therefore does not produce effluents. But AVLIS is less a concern with regard to cheating by developing states, because the level of technical sophistication is very high, and the technology could not be mastered by other proliferators without substantial technology transfers from outside whose detection probability is high.[109] This would be likely to be detected. New safeguards technologies must be developed for laser isotope separation.

Principally, the overview on the various mechanisms will never be complete, in other words, it can happen anytime that a new enrichment process with new side effects is invented. This may pose a problem in case a proliferator pursues the acquisition strategy of making use of a clandestine undeclared production facility, and characteristics for exports are not yet known. However, common to all processes is the presence of HEU which principally can be detected onsite, once a site has become suspicious.[110]

Noteworthy is the Hexapartite Enrichment Project, whereby 6 countries (Germany, Netherlands, Japan, USA, UK, Australia) agreed to place all civil centrifuge plants under permanent IAEA safeguards. The HSP was initiated in 1989 and was concerned primarily with divising a safeguards strategy to cover the new gas centrifuge enrichment facilities which began springing up in Western Europe and Japan during the 1970s. Thus the Capenhurst plants in the UK are permanently designated by the IAEA. This project also entailed the development of special verification techniques which enabled the implementation of satisfactory measures and an agreement between the IAEA and Euratom.[111] One interesting option would be to widen this agreement to include Russia and China.[112] Table 4 gives an overview on all known uranium enrichment plants worldwide.[113]

Country	Name, Location	Process	Status	Safeguards

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[109] This is especially true after national export controls and international regimes have been substantially improved in the last years. See for example H. Müller (ed.), Nuclear Export Controls in Europe, European Interuniverity Press, Brussels 1995.

[110] A historic example of such detection is Iraq where traces of HEU have been found on the clothes of hostages that had been held at a facility where some HEU production has taken place.

[111] D. A. Howlett, Euratom and Nuclear Safeguards, Macmillan, Southampton, 1990. See p. 225 ff.

[112] W. Walker, personal communication.

[113] Most of the information in this table is from: IAEA, The Nuclear Fuel Cycle Information System – A Directory of Nuclear Fuel Cycle Facilities, 1996 Edition.

Argentina	Pilcaniyeu	gaseous diffusion	in operation	ABACC, IAEA (NPT)
Brazil	Sao Paolo U enrichment plant, Resende	jet nozzle	under construction	ABACC, IAEA (1st cascade)[c]
China	Lanzhou[a] Heping[a] Shaanxi[a]	gaseous diffusion[a] gaseous diffusion[a] centrifuge[a]	unknown unknown under construction[a]	none
France	Georges Besse (Eurodif), Tricastin Saclay PL4, Grenoble Pierrelatte[a] Pierrelatte-P	gaseous diffusion laser chemical exchange gaseous diffusion[a] laser	in operation in operation in operation closed[a] under construction	Euratom
Germany	Urananreicherungsanlage Gronau (Urenco) Karlsruhe	centrifuge jet nozzle	in operation closed	Euratom, IAEA (NPT)
India	Bhaba Atomic Research Center, Trombay Rare Materials Plant, near Mysore[a]	centrifuge centrifuge[a]	unknown in operation[a]	none
Iraq	Al Furat Tarmiya Ash Sharaqat	centrifuge EMIS EMIS	destroyed	IAEA (NPT), UNSCOM
Japan	JNFL Rokkasho Ningyo-Toge Pilot Pl PNC Ningyo-Toge Enr. Asahi U-Enr. Labor.	centrifuge centrifuge centrifuge chemical exchange	in operation in operation in operation closed	IAEA (NPT)
Netherlands	Urenco, Almelo	centrifuge	in operation	Euratom, IAEA (NPT)
Pakistan	Kahuta	centrifuge	in operation	none
Russia	Ural Electrochemistry Kombinat, Ekaterinburg, (Sverdlovsk) Ekaterinburg Electrochemistry Kombinat, Krasnoyarsk Siberian Chemical Kombinat, Tomsk Electrolyzing Chemical Kombinat, Angarsk	gaseous diffusion, EMIS[a] centrifuge gaseous diffusion[a] centrifuge gaseous diffusion[a] centrifuge gaseous diffusion[a] centrifuge	closed[a] in operation closed[a] in operation closed[a] in operation closed[a] in operation	none
South Africa	Valindaba (Laser) Valindaba (Z-Plant Valindaba (Y-Plant)	laser helikon jet nozzle	under construction closed closed	IAEA (NPT)
UK	Urenco Capenhurst, A3 Urenco Capenhurst, E22 BNFL Capenhurst	centrifuge centrifuge gaseous diffusion	in operation under construction decommissioned	Euratom, IAEA[c]
USA	Paducah Portsmouth Oak Ridge Portsmouth	gaseous diffuion gaseous diffusion gasesous diffusion centrifuge	in operation in operation closed cancelled project	none

[a] Source: Albright/Berkhout/Walker[11]

[c] Facilities under IAEA safeguards or containing safeguarded material on 31 December 1995: http://www.iaea.or.at/worldatom/program/safeguards/95tables/facilities.html (as of 19 May 1997)

Table 4: Overview on uranium enrichment plants worldwide (1996, source: IAEA[113])

4.3.2 Plutonium and reprocessing[114]

Plutonium does not occur naturally but is produced in reactors by nuclear reactions between neutrons and U-238.[115] Pu-239 can react with more neutrons to form the heavier isotopes Pu-240, Pu-241, and Pu-242. The longer a fuel element stays in a reactor, the larger is the ratio of the higher isotopes which is less favorable though still not useless for nuclear explosives. But also the total amount of plutonium is increased.[116] Spent fuel contains plutonium, highly radioactive fission products and their decay products, and unaffected uranium. The plutonium can be separated from the spent fuel by chemical means which is called *reprocessing*. The most efficient reprocessing process is the PUREX process (plutonium and uranium recovery by extraction). Because of the high radioactivity of spent fuel, the process takes place under radiation protection. A small radiation protection device is a hot cell which can be used for the separation of small Pu quantities.

The following table (Table 5) gives an overview on all known reprocessing plants. Similarly as to enrichment plants, also for reprocessing plants, the basic safeguards approach is material accountancy that verifys the report of the SSAC, supplemented by containment and surveillance techniques.[117] Flows are measured at predetermined locations known as "key measurement points", and samples can be taken from various areas. There are several technical stages of reprocessing. In the first stage, the spent fuel is chopped and then dissolved, converting the material from discrete into bulk form. Then the fission products are removed and further processed, and finally, uranium and plutonium are separated from each other. Many of the process flows are highly radioactive, so measurements take place behind radiation shielding, and direct access is difficult. The large number of shieldings and the radiation protection measures make it difficult to maintain the overview on all potential diversion risks. In NNWS, the implementing of safeguards is taken into account already in the planning stage of a plant, and design verification can take place already during construction. This makes it much more difficult to pursue unmonitored diversion paths. Understanding the plant design is therefore a key element in the safeguardability of a plant. Similarly, the detailed knowledge of the operating history of a plant is of crucial importance in order to interpret measurement results. These methods serve mainly for verifying that no additional undeclared operations take place in operating declared facilities, and that no Pu is diverted from declared inventories. There are technical problems that add some uncertainties in results. Errors in calculated plutonium contents can at times exceed a significant quantity. They stem from biases in solution measurements, difficulties to determine the exact Pu content in spent fuel, time delays of sample analyses, and measurement limitations because of radioactivity. Safeguarding a civilian reprocessing plant that has not

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[114] On technical properties of plutonium see: Nuclear Energy Agency, Plutonium Fuel – An Assessment, OECD, Paris 1989.

[115] $\text{U-238} + n \rightarrow \text{U-239} + \gamma \rightarrow \text{Np-239} + \beta^- \rightarrow \text{Pu-239} + \beta^-$

[116] Isotope separation is much less efficient for plutonium than for uranium because the mass differences are smaller. It is not necessary for nuclear weapons. However, Pu-241 decays to Am-241 (americium), which destroys the crystalline structure of a Pu pit. In the U.S., aging Pu is reprocessed after some time to remove the americium. In 1994, a smuggled sample of Pu from Russia was detected in Tengen (Germany) that originated in Russia and apparently has been enriched in Pu-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.

[117] T. Shea, fn. 95; T. Shea et al., Safeguarding Reprocessing Plants: Principles, Past Experience, Current Practice and Future Trends, Journal of Nuclear Materials Management, July 1993; U.S. Congress, Office of Technology Assessment, Nuclear Safeguards and the International Atomic Energy Agency, Appendix A: Safeguarding Reprocessing Facilities, OTA-ISS-615, Washington, 1995.

formerly been under safeguards is more difficult. The first step of implementation is a thorough design analysis and reconstruction of operation history.

The verification that already shut-down facilities remain so is comparably easy by on-site inspections. Technical methods are seals, temperature and other signals measuring, and analysis of environmental samples. The analysis of Pu samples at reprocessing plants provides an unambigious indicator of the age of the sample.[118]

The other verification task is the detection of undeclared production facilities. Also reprocessing releases several characteristic effluents that can be detected and monitored from outside. They include particulates and gaseous fission products, especially noble gases that are not bound chemically. Reprocessing produces far more emissions than the operation of a reactor or enrichment and a clear evidence is likely. In addition, also chemicals could be released, and waste products must at least be hidden or disposed of somewhere. Countermeasures against detection are filters, shielding, and absorbation of noble gases, but the principle risk of being detected remains.[119]

Detecting the construction of a clandestine Pu production is more difficult because the technology is easier to procure than that of enrichment technology. A small reprocessing apparatus is not more than just a hot cell which principally can be produced indigeniously in many states. The method of detecting sensitive technology transfers and characteristic procurement activities is universal reporting, which is certainly only effective when applied by all states.

Country	**Location: Plants**	**Status**	**Safeguards**
Belgium	Mol, Belgonucléaire	stand by	IAEA, Euratom
Brazil	Sao Paolo Reprocessing	stand by	ABACC
China	Jiuquan complex (Subei County): reprocessing plant[a]	stand by or shut down (generally believed)[130]	none
	Guangyuan (Sichuan): reprocessing plant[a]		
France	Atelier Pilote, CEA, Marcoule	in operation	Euratom
	UP1, Cogema, Marcoule	in operation	
	UP2-400 LWR, Cogema, La Hague	in operation	
	UP2-400 NUGG, Cogema, La Hague	closed	
	UP2-800 LWR, Cogema, La Hague	in operation	
Germany	Wiederaufarbeitungsanlage Karlsruhe	shut down	IAEA, Euratom
India	PREFRE-Tarapur	in operation	IAEA[c]
	Bhaba Atomic Research Center, Trombay	in operation	none
	Kalpakkam	under construction	
Israel	Negev Nuclear Research Center, Dimona: reprocessing[a]	operating, shut down expected	none
Italy	Eurex SFRE-Pu Nitrate line, Saluggia	stand by	IAEA, Euratom
	Eurex-SFRE, 2 pilot plants	closed	
	ITREX, Trisaia	closed	
Japan	PCN Tokai Reprocessing Plant	in operation	IAEA
	JNFS Rokkasho Reprocessing Plant	under construction	

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[118] The ratio of Am-241 and Pu-241 rises with time.

[119] See also: OTA, fn. 108.

North Korea[c]	Radiochemical Laboratory, Bungang-Ri, Nyongbyon, including pilot plants[c]	closed	IAEA[c], NK in violation with obligations
Pakistan	Khushab (Punjab province): 1 CGR or HGR with nat. U[a]	under construction[a]	none
Russia [b]	Kyshtym Complex, Chelyabinsk: [a] RT-1 reprocessing plant[a]	closed	none
	Siberian Chemical Complex, Tomsk: reprocessing plant[a]	2 LWGR still operating, shutdown planned in 2000	
	Dodonovo, Krasnoyarsk:	1 LWGR still operating, shutdown planned in 2000	
	reprocessing plant	operating, but not for nuclear weapons	
	RT-2 reprocessing plant	under construction (civ.)	
UK	Sellafield: 8 GCR, B 204 and B 205 reprocessing plants, BNFL	in operation (civ.)	Euratom
	BNFL Enr. U chem. Facility (enriched U recovery), Springfields	in operation (civ.)	
	UKAEA Repr. Plant, Dounreay	in operation (civ.)	
	UKAEA Repr. Plant, Dounreay	in operation (civ.)	
	BNFL Thorp, Sellafield	in operation (civ.)	
USA	Hanford: 9 LWGR, Purex repr. plant[a]	closed[a]	none
	Savannah River: 5 HWR, F and H repr. plants[a]	closed[a]	
	Morris	closed	
	West Valley	closed	
	Barnwell	closed	
	Oak Ridge	cancelled project	

CGR = gas-cooled, graphite-moderated reactor (Magnox); LWGR = light-water-cooled, graphite-moderated reactor; HWR = heavy-water reactor; LWR = light water reactor

[a] Source: Albright/Berkhout/Walker

[b] Information on status from: Monterey Institute of International Studies and Carnegie Endowment for International Peace: Nuclear Successor States of the Soviet Union, No. 4, May 1996

[c] Facilities under IAEA safeguards or containing safeguarded material on 31 December 1995: http://www.iaea.or.at/worldatom/program/safeguards/95tables/facilities.html (as of 19 May 1997)

Table 5: Overview on all reprocessing plants and Pu production plants (1996, source: IAEA[113], except [a], [b]and [c])

4.3.3 General limits

Verification never can be 100 % sure, however, a large detection risk implies deterrence. It is enhanced by national technical means (NTM). For this reason, it is planned within 93+2 to grant the IAEA more access to intelligence information. In an FMCT, NTM can be implemented independently from the IAEA, similarly as in several other arms control treaties.

Reprocessing and enrichment do not only require plants but also spent fuel (e.g the operation of reactors) or feed uranium, respectively. The verification would be much more reliable if the other elements of the nuclear fuel cycle would be included, as is the case in NNWS. E.g., safeguarding spent fuel is far more simple than safeguarding a reprocessing plant, because it consists of discrete items which can be just counted and verified with uncomplicated measurement methods. Illegal diversion of a spent fuel element is easily detectable with a high degree of confidence and would cause an alarm. Determining only the correct content of plutonium in bulk material in contrast bears the uncertainties described above. Similarly, in case of HEU, when the uranium before the enrichment process is included already into the verification, the overall verification would gain much more reliability, and illegal plants would bear the additional risk that clandestine procurement of feed material is detected.

4.4 Different degrees of intrusiveness and their costs

The IAEA has worked out several potential verification scenarios:[120] the first is comprehensive safeguards similar as in NNWS including the 93+2 reforms, because "verification arrangements to anything less than a State’s entire fuel cycle could not give the same level of assurance" of compliance,[121] only a black box of previously excluded materials would be left out. The second scenario constrains the technical objective of verification to the provision that all production facilities of direct-use material are either shut down or converted to civilian use and subject to safeguards. It is subdivided in three alternatives with various degrees of intrusiveness and accordingly varying cost estimates. The working paper also points out that a substantial period of time would be required for the implementation, with different time-scales for different participants. A prerequisite would be SSACs in the NWS and the SON that meet international standards, which however do not exist everywhere and need extra efforts to be built up.

The total verification costs of a comprehensive verification system is estimated in the range of 140 million U.S. dollars. This must be compared to the expenditure of 67.5 million by the IAEA Department of Safeguards in 1993. This means that the IAEA budget for safeguards must be about tripled in case of universal full scope safeguards. The least intrusive alternative is estimated to cost about 40 million. Sometimes, NWS use the cost argument to oppose plans for universal coverage. But on the other hand, the prospect of investing into safeguards also in NWS seems to be realistically taken into account for the benefits of a cutoff at least in the U.S.[122] Judgements on costs are determined by priorities. As an example, the U.S. has allocated 1.5 billion dollars for the maintenance of the Nevada test site in the context of negotiating and signing the CTBT, which is about ten times as much as the international community would annually spend on universal full scope safeguards.

4.5 Specific verification problems

4.5.1 Naval fuel

Reactors for naval propulsion are frequently fueled with HEU. The reason is that such reactor cores can be made especially small. Reactor fuel can be either military or civilian. Also NNWS

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[120] 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, presented at the Workshop on a Cut-Off Treaty, Toronto, Canada, 17-18 January 1995.

[121] IAEA working paper, page 6.

[122] F. McGoldrick (U.S. Dep. of State) states 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." F. McGoldrick, U.S. Fissile Material Initiatives – Implications for the IAEA, Invited Paper, Proceedings of the Symposium on International Nuclear Safeguards, Vol. I, Vienna, 14-18 March 1994, p. 17f, quotation on page 20.

are allowed to possess military HEU for nonexplosive purposes without safeguards as long as it is not used for nuclear explosives although this has not happened so far. In INFCIRC/153 (§14b), it is foreseen that verification of fuel in a "non-proscribed military activity" is renounced as long as the nuclear material is in such an activity. The Agency and the State shall make an arrangement that identifies "to the extent possible, the period or circumstances during which safeguards will not be applied". This implies that it is not clearly defined so far under which conditions safeguards of fuel are interrupted. The interruption could be limited only to fuel in the reactor, or it could also be applied to specific naval fuel storage sites. "In any event, the safeguards provided for in the Agreement shall again apply as soon as the nuclear material is reintroduced into a peaceful nuclear activity." This agreement must not be confused with the specific safeguards agreements between the Agency and States.[123]

In case the scope of the FMCT covers only material produced after entry into force, it must however be clarified whether unverified production of HEU or other fuel for military naval reactors will be banned or not. In case it would be allowed, the FMCT would contain a large loophole which would hardly be acceptable to most negotiating parties. The treaty would be far less convincing. It is recommendable to ban unverified HEU production altogether. This is likely to be agreeable to all participants because of the large stocks of HEU already existing that can be used as naval fuel.

In case the scope of the FMCT covers more, e.g. also obligations to put all or some existing material under safeguards, special provisions must be found for naval fuel. While it is difficult to control fuel when it is actually in the submarine’s nuclear reactor, the storage sites should be included. Also managed access provisions for loading and discharging fuel from submarines should then be included in order to make sure that no illegal diversions take place. Normally, fuel stays in a reactor for many years. Since the quantities of naval HEU are huge (cf. Table 6), it cannot be kept out, should there be provisions for already existing material. Thefts of naval fuel have already become known, and international concern about the security of this material is rising.[124]

The quantity of HEU the U.S. has dedicated to naval reactors is estimated between 76 – 106 t which is 97 % enriched.[125] Russian naval reactors are reported to use various enrichments from 20 to over 90 %, the U-235 content is estimated between 47 and 190 t.[126] Most of them use 21 – 45 % with only few exceptions.[127] Britain purchases HEU for its naval reactors from the U.S, the total is estimated to 2 – 4 t weapon grade HEU.[128] France’s submarines have always used

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[123] As an example, INFCIRC/193 (between the IAEA and Euratom) is not more specific than IINFCIRC/153.

[124] Examples are: the theft of 1.5 kg HEU (90% enriched) in Podolsk (Russia), May-September 1992, and the theft of 1.8 kg HEU (30% enriched) in Adrejewa Guba (Russia), August 1993. See William C. Potter, Before the Deluge? Assessing the Threat Of Nuclear Leakage From the Post-Soviet States, Arms Control Today, October 1995, p. 9-16; Mikhail Kulik, Guba Adreeva: Another Nuclear Theft has been detected, Yaderny Kontrol, English Digest, Spring 1996, No. 1, p. 16-21.

[125] Albright, Berkhout, Walker, fn. 11, p. 86f.

[126] Same source, p. 112.

[127] O. Bukharin, Analysis of the Size and Quality of Uranium Inventories in Russia, Science & Global Security, Vol. 6, No. 1, p. 59, 1996.

[128] Albright, Berkhout, Walker, fn. 11, p. 118.

LEU fuel with an estimated average enrichment of 7 %.[129] China is believed to use only LEU fuel for its submarines.[130] This is summarized in the following table (Table 6):

Country	**Amount / t**	**Enrichment**	
USA	76 – 106	97 %	
Russia	47 – 190 (only U-235)	20 – 45 %	Some also up to 90 %
UK	2 – 4	97 %	imported from USA
France		LEU, ~ 7 %	
China		LEU	assumed

Table 6: Overview on nuclear submarine fuel in the NWS

One option explored by the British for overcoming the naval verification problem is to substitute otherwise unsafeguarded HEU for HEU that has ‘gone to sea’ or been incorporated in reactor fuel elements. But this would only be possible if sufficiently large stocks of unsafeguarded HEU would be allowed. However, there is concern that knowledge of HEU inventories in submarines would reveal information about operational capacities.[131] Another issue for Britain is access to US-origin HEU under the US-UK Mutual Defence Agreement. If safeguards on stocks were included in the FMCT, transfers might have to be abandoned under an FMCT.[131]

In principle, HEU is not necessary for naval reactors because they can also be driven with LEU. The technical advantage of HEU is that the volume of the reactor core can be made especially small. However, in the last years, new much more dense reactor fuels have been invented.[132] They enable the replacement of HEU fuel by LEU in almost all civilian research reactors and allow nevertheless to keep the power and volume of the reactor core. It has already successfully been applied in many reactors previously fueled with HEU. 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.[133] The funding of the research and development of the new fuel has specifically been motivated by concern about the rising amounts of civilian HEU transfers and the resulting proliferation dangers.[134] Civilian research reactors and military naval reactors are technically comparable. Similarly to civilian reactors, also conversion of military reactors could be possible. The U.S., Russian, British naval reactors have been designed before the invention of the new fuels, so the possibility of conversion is likely. In case all naval reactors are converted, the verification must still ensure that production facilities produce only LEU but not HEU, but an exemption for more intrusive verification of naval fuel use would constitute a smaller loophole.

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[129] Same source, p. 125.

[130] L. Gronlund, D. Wright, Yong Liu, China and a Fissile Material Production Cutoff, Survival, Vol. 37, No. 4, Winter 1995

[131] W. Walker, personal communication.

[132] IAEA, Research reactor core conversion guidebooks, Vol 1-5, IAEA-TECDOC-643, April 1992.

[133] The only one would be the newly planned new research reactor FRM-II at Garching.

[134] In the U.S. RERTR program, about 50 mio. $ have been spent, in the German AF-Program 51.1 Mio DM, see also fn. 72.

4.5.2 Tritium

The production of military tritium which is contained in all modern nuclear warheads gives rise to a further difficulty because it might be confused with plutonium production. It is not possible to renounce the use of tritium for warheads, since this would require new warhead designs, e.g. the need for nuclear testing banned by the CTBT. Tritium is a radioactive isotope of hydrogen with a half life of about 12 years. This implies that nuclear disarmament does not abolish the need for new production, it only delays it, more precisely, each reduction of nuclear warheads by the half would delay the need for new tritium for another 12 years.[135] A ban on military tritium production is therefore not acceptable to the NWS unless there would be comprehensive nuclear disarmament. Tritium is also used for several civilian applications, including scientific civilian fusion research. The part of the wording of the negotiation mandate which limits the scope on only fissile material but excludes fusion material was not challenged.

Tritium does not occur in nature except in unretrievable traces and must therefore be produced artificially.[136] It is also used for some civilian applications. There are several production methods which are all based on nuclear reactions requiring a neutron. These reactions are:

1. lithium-6 path: Li-6 plus a neutron forms tritium plus helium ($\text{Li-6} + n \rightarrow T + \text{He-4}$)
2. heavy water path: deuterium plus a neutron forms tritium ($D + n \rightarrow T + \gamma$)
3. helium-3 path: He-3 plus a neutron forms tritium plus hydrogen ($\text{He-3} + n \rightarrow T + H$)
4. fission rod path: one tritium nucleus is formed in about 10 000 fissions as a third fission product (ternary fission)

High enough neutron fluxes principally can be produced in nuclear reactors or by *spallation neutron sources* which are devices involving particle accelerators.[137] To supply the neutrons, protons are energized in a linear accelerator and used to bombard a heavy-metal target made of tungsten and lead, creating neutrons in a process known as *spallation*. Spallation neutron sources are an advanced and expensive technology that cannot be acquired clandestinely in less developed states. They are normally used for civilian scientific applications. Neutrons can also be used for the production of plutonium because it is breeded from U-238.

The most important tritium production methods are listed in the following:

- **Lithium path:** placement of Li-6 into a nuclear reactor fuel rod or next to the core where it would still be hit by enough neutrons. In fast breeders, such a rod would be placed into the blanket. In principle, any reactor can be used either for plutonium or lithium production. Safeguards as applied today make sure that no illegal diversion takes place. This includes measurements identifying fuel composition and tracing all fuel. In case lithium is contained in a reactor core, this would not constitute a violation of any nonproliferation obligation, however, it could reveal that tritium production takes place and would allow some assessment of its quantities. But the tritium needs of the NWS are roughly known anyway, and in the U.S., figures are also publicly discussed. Exempting such reactors from safeguards

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[135] The arms reductions are releasing large amounts of tritium – decades' worth – that the US and Russia can stockpile. If comprehensive disarmament were envisaged in a comparable time, they might live with a ban on tritium production. Britain and France may have a greater problem because their reductions are smaller percentage-wise.

[136] For a detailed overview on tritium uses, production and eventual control see Colschen and Kalinowski, fn.76. Most of the technical information in this section is drawn from this source.

[137] Also civilian fusion research aims at producing high reaction rates, e.g. neutron fluxes. However, the realization of devices with relevance for fissile material control measures is still far in the future.

would constitute a wide verification loophole. It is also possible to use a spallation neutron source with lithium.

- **Fission rod path:** the tritium can be recovered from spent fuel at reprocessing plants. Since verification of reprocessing would take place anyway, the fact that tritium is recovered would be revealed. Tritium removal is part of the process anyway because environmental contamination must be minimized. It can also be recovered without reprocessing by heating the spent fuel. The quantities available from spent fuel are much smaller than those from other production methods.
- **Heavy water path:** in heavy water reactors such as the Canadian CANDUs, tritium is formed in the cooling water and can be recovered. The quantities obtainable are comparatively large. Canada for example has a large civilian tritium production industry. This method cannot be confused with plutonium production and does not pose a verification problem. However, the NWS do not have such indigenous production capacity. They could buy tritium from Canada or other suppliers, but whether these countries would be willing to sell material for nuclear weapons is doubtful.
- **Helium-3 path:** helium can be lead through additional pipes within a reactor core and the tritium can subsequently be extracted. In a high temperature gas cooled reactor, tritium is automatically produced in the coolant. In order to verify that no undeclared plutonium production takes place, it is sufficient to control all fuel. Additional tritium extracting devices applied only to the gas flows must not extra be controlled as long as the design verification has made clear where diversion risks in the facility exist. Also neutrons from a spallation neutron source can be directed on a target consisting of a continuous He-3 flow. For this method, the neutrons must first be slowed down, e.g. by collisions with water, to make the process more effective.[138]

The most efficient and cost effective production method is placing lithium in nuclear reactors. This procedure has been used by all NWS. It is the most likely method also to be used in future. However, it is also the one that is the most likely to be confused with plutonium production. Indeed, in the past, the same reactors have often been used for tritium and plutonium production. Only in case the verification would be the weakest scenario, e.g it would include only verification at reprocessing and enrichment facilities and would not cover the other elememts of the fuel cycle, especially spent fuel and reactors, only then also tritium production reactors would be left out. As soon as verification of reactors is included, it would not be convincing any more to exempt tritium production reactors, although a demand for a provision that allows states to withdraw production facilities for military tritium production is likely to be raised in negotiations. However, this would create a big loophole. This is also the opinion of the IAEA: Depending on whether naval fuel and tritium production facilities will be placed under safeguards or not, the "level of assurance against e.g. the diversion of fissile material from amounts produced for such non-explosive uses permitted by the treaty could be high or low."[139] It must at least be verified that the fuel elements shipped to the extraction plant are indeed those containing tritium and not others containing plutonium. However, it is not necessary to measure exact quantities, therefore the amount of classified information revealed to inspectors is hardly relevant.

In the U.S., the aging tritium production reactors at Savannah River Site have been shut down already several years ago for safety reasons. In 1995, the Department of Energy issued a so-

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[138] The cross section for the reaction is especially high for thermal neutrons.

[139] Thorstensen, fn. 100, p. 4.

called "dual-track strategy to assure a future tritium source".[140] This includes discussions with the nuclear industry on the use of civil reactors for later tritium production. Meanwhile more concrete plans have been designed and a test production is already planned in a civilian reactor.[141] In case this plan proceeds, international controls would have to be allowed in reactors that are also used for military purposes. The alternative to the dual-track strategy would be to design, build, and test critical components of an Accelerator-Produced Tritium (APT) system for production of tritium. The Department will select one of the alternatives at a later date to serve as primary source of tritium for the nuclear weapons stockpile. If feasible, the other alternative would be developed as a back-up source. In APT, tritium is made by capturing slowed down neutrons from a spallation neutron source in He-3 flowing through the target. The tritium is extracted from the gas continuously.

4.5.3 Dual-use and military facilities

In military facilities, the problem can arise that the owners might be reluctant to submit them to too intrusive a verification because too much sensitive information can be revealed. Such facilities could be former military production sites, maintenance facilities still in use, or dismantlement facilities for nuclear warheads. Maintenance facilities serve for refabrication of aged warheads, repair, technical evaluation and stockpile stewardship, and removal of tritium in aged plutonium. While closed facilities do not pose problems for verification, verification in maintenance and dismantlement facilities is unlikely to be acceptable for NWS. Similarly, the SON have probably facilities which are candidates for similar problems. The sensitive information can be the following:

- **The isotopic composition of nuclear materials:** especially Russia is reluctant to reveal the exact isotopic composition of its weapons HEU or plutonium.[142] It cannot be excluded that inspections and measurements on former military sites could find traces of weapon materials, even if this has been removed prior to the start of inspections. In the several international studies on the disposition of Russian weapons plutonium, only artificial numbers were used, mostly typical numbers from the U.S. arms control literature. In Russia, this is still regarded as highly classified information. Also in the U.S.-Russian HEU deal, only diluted uranium is transferred to the U.S. so that the original isotopic composition is unknown. In case this information would be revealed, no additional proliferation danger would be created, because it is already generally known that NWS prefer a high Pu-239 content for their weapons plutonium and a high U-235 content for their weapons uranium. On the reasons for this secrecy it might be speculated that either it is simply an untouched tradition, or surprises could be revealed, either that the composition has an embarrassingly low quality, or even the contrary, e.g. that plutonium has been further enriched.[143]

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[140] U.S. Department of Energy, Availability of the Tritium Supply and Recycling, Final Programmatic Environmental Impact Statement, October 27, 1995.

[141] D. Airozo, DoE submits report to NRC on tritium test assemblies; Nuclear Fuel, December 30, 1996; D. Airozo, O'Leary expected to add FFTF to tritium production options, Nuclear Fuel, January 13, 1997; D. Airozo, DoE to run tritium test at Watts Bar-1; Nuclear Fuel, February 10, 1997.

[142] In the U.S., the isotopic composition 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, 14-18 March 1994, Vol. II, p. 639. In Russia in contrast, also the isotopic composition of disarmament materials is still classified.

[143] Indications in this direction can be seen in the Tengen smuggling case (fn. 116).

- **The amount of material needed for one warhead:** it is also possible that at such sites material pieces or tools can be found that reveal the size of nuclear weapon pits. The pit is the fissile part of a nuclear warhead, and in modern devices, it is always shaped as a hollow sphere. The size and dimensions of pits are classified in all nuclear weapon states, and there are presumably wide variations. Although again the proliferation danger would not be increased if some dimensions became known, an important conclusion could be drawn: it is an estimate of how much material was in the pit, together with knowledge on the yield of a warhead, even estimates of the factor by which the pit could be compressed are possible. Such conclusions are regarded as far too sensitive even after the end of the Cold War. An urgent task at such a facility is therefore the removal of such parts and tools as soon as possible in order to prepare it for the start of safeguards. This work, if necessary, is urgent anyway in order to minimize proliferation dangers.
- **Design information of warheads:** in case a fissile material production facility or storage site is colocated with a warhead factory, even machinery for pit fabrication and conventional explosive ignition technology could be around. This is especially believed to be the case at some Russian facilities. This kind of information is highly proliferation relevant and must therefore be accordingly protected. An urgent task for the owning state is therefore the physical separation of fissile material production, storage sites (at least those for future civilian material) and weapon manufacture sites, in order to prepare for future inspections. In case such different facilities are colocated very closely, special arrangements will be necessary that protect the sensitive parts. Also transports to and from such special buildings must be exempted. The absence of illegal enrichment or reprocessing could still be verified to a certain degree of confidence from outside by environmental monitoring of effluents. The first task when safeguards are initiated is verifying the design information of a facility. Too close integration of different illegal or sensitive legal activities might pose initial problems, but a timetable can be implemented until when the separation should be completed. Also the interieurs of weapon dismantlement facilities cannot be submitted to inspections. Although it is recommendable and probably possible to verify to a certain extent the dismantlement of warheads, this should be negotiated independently from the FMCT.[144] But the early application of safeguards on material from dismantlement will certainly be a topic in the negotiation.[145]

An approach for safeguards on nuclear material capable of revealing classified information could be to replace IAEA materials accounting procedures as a start by transparency measures that rely on a combination of item accounting and qualitative measurements to confirm emissions characteristic of the declared nuclear material while avoiding disclosure of sensitive data. Weapons components can reveal too sensitive information. At least, classification guidance in the U.S. allows a measurement of the total radiation at a fixed distance from the weapons

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[144] There exist already some studies showing the principal possibility of verified warhead dismantlement without revealing untolerable design details: S. Fetter, V. A. Frolov, M. Miller, R. Mozley, O. Prilutsky, S. N. Rodionov, and R. Sagdeev, Detecting Nuclear Warheads, Science & Global Security, Vol. 1, p. 225-302, 1990. A report on an experiment on the verified dismantlement of nuclear warheads, undertaken by the United States Arms Control and Disarmament Agency in 1969, has recently been partly declassified: ACDA, Final Report: Field Test FT-34, Demonstrated Destruction of Nuclear Weapons (U), Jan. 1969. For a short summary of the results see: F. v. Hippel, The 1969 ACDA Study on Warhead Dismantlement, Science & Global Security, Vol. 2, p. 103- 108, 1991.

[145] See T. A. Shea, Putting Fissile Materials from Weapon Dismantlement under Safeguards, Workshop on Fissile Material Production Cut-Off, Geneva, 29-30 June 1995.

component container. At the same time, NWS should relax their classification laws.[146] The following table gives as an example the civilian-military integration of the Russian HEU production facilities.[147] All of them would be submitted to FMCT verification regardless of the chosen verification scenario because they are former military production sites. One facility listed in this table, the Ural Electrochemistry Plant, might be a candidate for dual-use problems because of its colocated storage and manufacturing of HEU weapons components. Problems with such colocation in France and Britain do not exist because of the Euratom safeguards, but maintenance, americium removal or future dismantlement of warheads could cause similar problems.

Facility/location	**Fraction of total Russian enrichment capacity**	**Defense activities**	**Civil activities**
Ural Electrochemistry Plant / Verkh-Neyvinsk	49 %	• Top cascade in HEU production (past) • Storage and manufacturing of HEU weapons components • Blending of HEU to LEU[a]	• enrichment services for domestic needs and exports • U conversion
Siberian Chemical Combine / Tomsk 7	14 %	• Initial cascade for HEU (past) • HEU processing • HEU oxidation prior to blending to LEU[a]	• U enrichment • U conversion
Electrochemistry Plant / Krasnoyarsk-45	29 %	• Initial cascade for HEU production (past)	• U enrichment
Electrolyzing Chemical Combine / Angarsk	8 %	• Initial cascade for HEU production (past)	• U enrichment • U conversion

[a] For the U.S.-Russian HEU agreement. Note that the Russians still count this as military and not civilian activity.

Table 7: Examples of military-civilian integrated fuel facilities (Source: Bukharin[147])

Another example of dual-use problems is military HEU and other uranium from the former Soviet military complex that is located in Kazakhstan.[148] Kazakhstan, in an effort to implement full-scope IAEA safeguards, submitted infomation on this material to the IAEA. Russia so far has protested against the IAEA safeguards because it considers the information too sensitive. Similar problems arise at the former test site in Semipalatinsk, where Kazakhstan as a NNWS has legal obligations which are contradictory to Russian interests as a NWS. Before safeguards can be implemented, these problems have to be solved.

4.5.4 Implementing MC&A and SSACs

Most plants in the U.S., Russia, China, and in the SON have not been planned to take up safeguards. Therefore, designated measurements points, designs that specifically facilitate an overview on material flows and define strategic points, access for taking samples, installations that

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[146] J.T. Markin, W.D. Stanbro, fn. 142.

[147] O. Bukharin, Integration of the Military and Civilian Nuclear Fuel Cycles in Russia, Science & Global Security, Vol. 4, No. 3, p. 385, 1994.

[148] G. Pshakin, Methods to cope with Material Protection Problems in Russia and CIS: how to draw a line between civilian and military sector, Paper presented at the International Seminar on Fissile Material Security in the CIS, Bonn, 7-8 April 1997.

enable the applications of tags and seals, limitations for human entries, and other favourable prerequisites for the installation of control equipment might be lacking. Before an SSAC can effectively work, the MC&A at the facilities must be implemented. Improvements are necessary and underway also independently from the cutoff, at least in Russia in the context of the various international collaboration projects for the improvement of nuclear security.[149] This is a challenge but not an insurmountable obstacle.[150] A similar though smaller effort was necessary for the implementation of full-scope safeguards in South Africa.

Similarly, SSACs compatible with IAEA standards are still lacking in some countries, e.g. Russia.[151] The material accountancy necessary to set up an SSAC first needs reforms and improvements. While in the U.S., 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 either in China, and the SON. Russia at the time being is reforming its system. Before, the key element was control over people but not technically over nuclear material. A result of controlling people is the tradition of extreme secrecy concerning the nuclear military complex. Each facility had deadlines for reporting, but the reports were based on bookkeeping and individual responsibilities, not on physical measurements. In November 1995, a new Law on the Use of Atomic Energy was put into force in Russia. This law introduces the internationally recognized principle of measured material balance as a basic concept of the Russian SSAC in contrast to controlling people. However, the implementation of all provisions in the new law will still take time. Steps that must be taken include the implementation of regulations containing technical, organizational, and reporting requirements for MC&A, implementing the interaction between the MC&A in a facility and the SSAC, measurement systems at facilities, preparing of the technical initial physical inventory and the implementation of the according regulations, training of personnel, and the transition from the old to the new system. There are many problems that must be overcome, not only the well known financial shortages but also those of organizational nature:

It is not yet clear which Russian agency will be reponsible for which kind of controls and regulations.[152] In general, the present concept specifies the following: Minatom is responsible for effecting the MC&A of nuclear materials intended for civil and defense purposes, the Ministry of Defense for effecting the MC&A of nuclear materials for defense purposes, Gosatomnadzor for the oversight of nuclear materials intended for peaceful purposes, and the State Customs Committee controls the transport of nuclear materials across Russian borders. There seem to be many overlaps and rivalries causing problems that must be solved before the new SSAC can be complete. However, collaboration with the IAEA can start long before this, and the preparations and installation of safeguards can take place much in parallel.

In most NWS and SON, different authorities are responsible for the control of the military or civilian nuclear cycles. These states might anticipate problems in the transition of material and

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[149] Cf. section 2.4.1 Security and transparency of fissile materials from nuclear disarmament and of the nuclear weapon complexes.

[150] The IAEA assesses itself well prepared for this task. See Thorstensen, fn. 100.

[151] Source of this section: A. N. Roumyantsev, Establishing a SSAC in Russia: structural, organizational, budgetary and political problems, Conference on Fissile Material Security in the CID, DGAP, Bonn, April 7-8, 1997.

[152] Y. G. Volodin, Russian Efforts to Improve Regulation and Maintenance of the Account, Control and Safeguards of Nuclear Materials at Nuclear Installations, Bonn Conference (fn. 151). Volodin is a Gosatomnadzor official. In this paper, the SSAC is called "State MC&A system".

facilities from military to civilian use. It is recommendable that they exchange their experiences and start collaboration on solving such problems.

Because of these problems, it must be expected that certain time scales after entry into force will be necessary for the implementation of the verification. However, it is strongly recommendable to specify these times. Treaty language like the rather vague "as soon as practicable" could delay success indefinitely. It would be more advisable to negotiate a protocol for timetables for specific steps, perhaps combined with technical collaboration programs between states, the IAEA, Euratom or other SSAC agencies.

4.6 A universal verification system?

An effective and nondiscriminatory treaty will need universal full-scope safeguards. However, there are several political and technical hurdles: paving the way for universal acceptance within the NWS and SON is a political problem and will take time, implementing material accountancy systems in these countries is a technical problem and will take time and money, implementing the safeguards is also a technical problem and will take more time and even more money. The long term goal must be to create sufficient confidence that no material is being produced or diverted from civilian use for nuclear explosive purposes. So far, the basis for this verification goal is INFCIRC/153 and its reform 93+2. The costs of a universal system based on this are about three times as high as the current costs. Also the organizational efforts will have to be tripled, e.g. the number of inspectors will be much higher. One of the objections against a universal system is sometimes that the organizational efforts will become unsurmountable because of the complicated procedures of appointing inspectors.

Too high costs, too much organization, too sophisticated formal procedures, doubling of efforts by the IAEA and Euratom, too low effectiveness, and too many inspections in places where confidence is high anyway, these were already some of the elements of the criticism that has led to the 93+2 negotiations. One of the effects of the reform will be lower costs by simultaneously enhancing the probability of detection of noncompliance. 93+2 is a departure from the principle of verifying declared facilities and materials to the principle of search for nondeclared activities which is more adequate to the original motivation: the prevention of unwanted proliferation. It has some potential for more universality as well as for more efficiency.

On the long term, it will be necessary to work on more fundamental reforms with the goal of a universal system with no more distinction between NWS and NNWS.[153] Such a future system as a whole must be different, characterized by a new safeguards culture, based more on technical and political judgement than on the schematic implementation of quantification measures. A reform will have to address several criteria: finances, organization, decision making, effectiveness, concern about noncompliance, and finally also underlying principles, e.g. standards such as significant quantities. A reform will become necessary anyway even without a cutoff because of the various nonproliferation and disarmament problems that need new solutions.[154] Activities are already underway and more will come, starting with the implementation of 93+2 and safeguards on declared excess weapon materials. A new global approach can also bear the potential of laying the basis for a future nuclear weapon free world. The other way round, the

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[153] J. H. Gösele, H. H. Remagen, G. Stein, A German view on safeguards beyond 1995, Proceedings of the Symposium on International Nuclear Safeguards, Vol. II, Vienna, 14-18 March 1994, p. 701; H. Blankenstein, Political Considerations on the Future of Safeguards, Proceedings of the 17th Annual Symposium on Safguards and Nuclear Material Managements, p. 21, Aachen (Germany), 9-11 May 1995.

[154] See section 2.4. Other new initiatives on fissile material – heralds of a paradigm change?

path towards nuclear weapon free world can be taken as an underlying principle: to quote William Walker, "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".[155]

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[155] Fn. 11.

5 Problems, questions, conclusions, recommendations

The problems hindering progress in CD negotiations of an FMCT is mainly the current stalemate in the CD. Substantial concessions would be needed, but the desire to make concessions to the NAM at the CD is not strong – partly because constituencies within the NWS regard the FMCT and its regulations as a nuisance. On the other hand, the interest in getting work started on enhancing the security and transparency of fissile material stocks elsewhere is visible and provides a basis for more joint undertakings. Interests differ more in details how such progress should look like and where it should be implemented, whether it should be applied only to certain targets, e.g. civil plutonium in NNWS, undeclared fissile materials in SON, unsecure fissile materials in the former Soviet Union, or storage sites in the U.S.; or whether the efforts should also be driven by a vision, be it the vision of universality and a more effective verification system, or be it even the vision of a nuclear weapon free world.

The reason for the current stalemate is the radicalization of positions: India's "all or nothing" nuclear disarmament fundamentalism stands against the obduracy of the NWS not to grant any concessions towards disarmament negotiations. India insists on an ad-hoc committee on comprehensive nuclear disarmament as condition for starting negotiations on an FMCT while this is unacceptable for the NWS.[156] The underlying conflict is the same as in the CTBT negotiations, it is the question who is the target, the NWS or the SON? Although India has become quite isolated, a repetition of the strategy to push it by international pressure towards accepting a treaty it has hardly influenced at all will not work again.[157] As long as India does not get a realistic expectation that there is something it might gain from an FMCT, it will have no interest in repeating the CTBT experience. The question has been raised whether the CD is still the appropriate negotiation forum.

Two alternative and one complementary scenarios of how to get out of the stalemate can be imagined:

One scenario tries to keep the negotiations within the CD: in this case, India must be made believe that there can be more than only isolation and international pressure. The positive incentives must be the prospect that India can have some serious influence, that there is some potential for a face-saving compromise that will not look like a humiliating defeat, that it will be treated as a respected and important negotiation partner, and that it later on can point out to some progress towards nuclear disarmament. So far, these incentives do not exist and must be created. This could be done with informal but serious talks between the U.S. and other major negotiation partners on the one side and India on the other, but it must be complemented by some visible actions: An appropriate compromise could be the implementation of an ad-hoc committee without negotiation mandate in the CD on the prospects of nuclear disarmament. This would have several advantages: it would be face-saving for India because it would address the topic of comprehensive nuclear disarmament, as well as it would be face-saving for the NWS, because the forum would not have a negotiation mandate. And it could have the very important function to learn more about interests and positions, which would have the effect of avoiding surprising stalemates in the last minute, e.g. the "sudden" conflict on the entry

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[156] E.g. Ambassador Stephen J. Ledogar, U.S. Representative to the CD: "The Conference on Disarmament (CD) cannot at this point be a forum for negotiation of comprehensive nuclear disarmament", in an interview with Reuters and the United States Information Agency, February 14, 1997.

[157] See Appendix I: S. Keller, Some striking similarities and some telling dissimilarities between a cutoff convention and a CTBT.

into force clause of the CTBT which in fact was the "disarmament versus nonproliferation" conflict. If India then still rejected any cooperation, it would lose far more sympathies than it does now. This scenario does not mean that at the end of negotiations India will automatically sign and ratify an FMCT, but it could help to get the negotiations going. However, it must be ensured that the NWS will take the risk that an FMCT might eventually start first without some of the SON. As long as positions on both sides remain as fundamental as they are now, there is not much hope for progress in the CD.

Another scenario would shift the negotiations to another forum without India. Two principle variations can be distinguished: one is the creation of a new forum, e.g. in Vienna, perhaps in cooperation with the IAEA who is already involved in various other negotiations on fissile materials. Similarly to the CD, this forum would encompass interested states, preferably all NWS, and several NNWS including those with strong interests, e.g. those with nuclear industry and those interested in nuclear disarmament. Probably, this forum would reflect similar positions as the CD but would avoid the deadlock, and therefore would probably be able to work out a consensus on a treaty text. However, there are two major disadvantages: firstly, such an endeavour would kill the CD. The CD is the UN’s major forum of disarmament negotiations, and the creation of a competing forum would signal the perception of failure. It would also signal the perception of the international community that the previous success, the negotation of the CTBT, will not be completed because no hope would be seen that it will ever enter into force because of India’s abstinence. Secondly, this procedure would harden India’s position even more and the likelihood that it may one day join the treaty will drop towards zero. For India, this would be a provocative reminiscence of how the CD was circumvented, when a group of states submitted the CTBT draft to the UNGA by ignoring India’s objections. India will claim that it will never sign a treaty in whose negotiations it has not participated.

The other variant of this scenario is a small negotiation forum only among the NWS. Since they have a lot of common interests and problems, they might be successful in designing a draft that will serve their interests. In all likelihood, this draft would represent the original idea of banning future production, but any more obligations, e.g. declaring excess materials and timetables to submit them to verification are very unlikely. More than only symbolic verification and more universality of verification measures are hardly to be expected because no negotiation partner will press for them. An FMCT negotiated on an "NWS only forum" will certainly leave many unsatisfactory loopholes. The credibility of the new FMCT treaty as disarmament symbol would not be very strong. The NNWS would be offended because they would be excluded from a forum where they have strong interests and a good will to contribute constructive work and efforts. There is still lingering resentment of the negotiations of the Partial Test Ban Treaty that was negotiated only among the NWS but then opened for signature of all. To be on the one hand good enough to share the verification costs that must be expected but on the other hand to be excluded from any decision making and influence will cause severe resentments. It will also damage the NP regime because the FMCT will become another symbol for discrimination instead of a symbol for an important step towards nuclear disarmament.

A third scenario can be pursued independently from the others and has already started. It is the step-by-step approach of many measures leading to more security of fissile materials. The cumulation of many of these activities will finally pave the ground for an FMCT and will greatly contribute to successful negotiations. One of these measures can indeed be a negotiation or discussing forum only among the NWS on fissile material policies aiming at nuclear disarmament and enhancing transparency and security.[158] It can originate from the trilateral U.S.-

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[158] N. Numark suggests a bilateral treaty on the reduction of disarmament materials: N.J. Numark, Get SMART: The Case for a Strategic Materials Reduction Treaty, and Its Implementation, paper presented at

Russian-IAEA negotiations. Such talks could firstly lead to more unilateral transparency initiatives and voluntary safeguards, then to more bilateral and multilateral inspections, which then could become legally more and more binding. The extent of verification could be gradually increased. The technical implementation would take time anyway, and the political acceptance could be enhanced in parallel.[159] The NNWS should support all these initiatives with the goal to give the IAEA a major role. However, it must be avoided to call any results of such talks already an FMCT treaty.

This development should be complemented by official declarations of the NWS to keep their moratoria on fissile material production for nuclear weapons, similarly as the testing moratoria helped paving the way for the CTBT. Similarly, also India, Pakistan, and Israel could declare a moratorium, eventually linked to the moratoria of the NWS.[160] Also regional initiatives, especially in South Asia or in the Middle East could incorporate moratoria and bilateral or regional transparency measures.[161]

The NNWS should keep pushing and developing initiatives, e.g. the idea of a nuclear weapon register, even if there is the risk of some temporary ill-feeling. They should also push for an ad-hoc committee for disarmament in the CD, though without negotiation mandate, and they should motivate initiatives to integrate India that will help overcoming the dead-lock. It is important that they continue the policy of relating all nuclear disarmament activities, e.g. technology transfer for plutonium disposition to IAEA safeguards. The NNWS are especially well suited to suggest compromises between the current extreme positions since they are interested in both nonproliferation and disarmament.

The FMCT will only acquire real momentum, if the U.S. comes to recognize that it is a vital part of the arms control agenda – not least because it will be a driver of the necessary policy and institutional reforms. The U.S. has to be prepared to make concessions, and to use its heavy influence to make it happen. Especially Russia and China might be reluctant in the beginning to see the benefits of an FMCT because their nuclear complexes would need to undergo fundamental reforms and some traditions of secrecy would have to be abandoned.

The FMCT is a major next step on the nuclear arms control agenda, explicitly mentioned in the Principles and Objectives. It is a key element of nuclear nonproliferation and disarmament policy. In principle, its verification is possible, and far less contested than was once the verification of a testban. There are no technical, but only political obstacles that can be overcome if the political will is there. It is important that the idea of the FMCT is not lost, even if short time progress is unlikely.

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the International Conference on Military Conversion and Science: *Utilization/Disposal of Excess Weapon Plutonium: Scientific, Technological and Socio-Economic Aspects*, Como, Italy, March 19, 1996.

[159] A concrete proposal in this direction has been made by von Hippel and Fetter, fn. 13. See also Gronlund and Wright, fn. 68.

[160] F. von Hippel, The Fissile Cutoff: Is There a Way Forward?, Paper presented at the Conference on "The Future of Nuclear Weapons: A U.S.-India Dialogue", University of Pennsylvania, May 5-8, 1997.

[161] See for example A.H. Nayyar, Prospects and Constraints for a Bilateral Verifiable Fissile Material Cutoff in South Asia, Paper presented at the Symposium on Science, Arms Control and Global Conflicts, Oberwesel, Germany, July 8-18, 1994.

Appendix I: Some striking similarities and some telling dissimilarities between a cutoff convention and a CTBT

by Stefan Keller

Presentation at the workshop on "The Cut-Off-Convention - Interest, Scope, Verification and Problems", Session "Questions and Problems", Bonn, December 12, 1996

Introductory remarks

The title "questions and problems" is sufficiently wide and flexible to shed light on our topic from a different point of view. I will not try to re-examine all the intricacies and technicalities of a Cut-off Convention. Thérèse Delpech, my French co-presenter, having worked on this issue for years, is in a much better position to do so. My approach to this topic is very much guided by my personal experience as a participant in the test-ban negotiations and to the consultations on the mandate of a Cut-off Ad Hoc Committee in Geneva. In the course of the years in Geneva I found some striking similarities and some telling dissimilarities between a cut-off convention and a CTBT.

My conclusion

My conclusion or the lesson I have drawn from those negotiations could be summed up as follows:

It sounds simple and mundane. But you have to identify and strike a balance between different interests. Even in the field of nuclear weapons, it does not suffice to look for that balance within the group of P5. The main conflict of interests "nuclear disarmament versus nuclear non-proliferation" can spoil any negotiations if not adequately handled. Take the case of the CTBT-negotiations. By a sophisticated negotiation management this conflict of interest was relegated to the end game of negotiations, relegated to so called technical treaty-clauses such as the entry into force clause and never adequately tackled in an open discussion. This silent procedure has led to the semi-failure of those negotiations. The same approach will almost certainly lead to the complete failure of cut-off negotiations. If there will be any.

In the last phase of the CTBT-negotiations, the above noted conflict was embodied by India on the one side and the P5 (in particular UK, China, and Russia) on the other side. India could be isolated and complete failure of the negotiations could be prevented as the overwhelming majority of non-aligned countries preferred to bring home some modest imperfect results rather than go back to square one with no international commitment by the P5 to a test ban at all. India failed to claim equal standing to the P5. To put it more bluntly: The U.S. as the major nuclear power was willing to compromise about Chinese positions but not about Indian positions. It left Indian politicians deeply humiliated and suspicious of any new multilateral treaty initiated by the P5. The Indians will take their revenge if they can avoid being isolated. This is a very bad omen for a cut-off convention.

Let me say something about Pakistan as this country is always quoted as the bad guy when talking about the endless story of a cut off convention. It is true that Pakistan has spoiled all attempts to bring about cut-off negotiations. But it is also true that nobody cared too much about that failure (maybe beside the Canadians) as long as CTBT-negotiations were going on.

Pakistan as a client state of China would not have been able to stand the combined pressure of the P5, Western countries, and most non-aligned countries and block indefinitely cut-off negotiations. But India would do so if that suits its policy. It has amply demonstrated that capacity. Thus, Pakistan's opposition remains a side issue, already superseded by India's opposition to any multilateral treaty in the field of nuclear weapons which might isolate them once more.

Any attempt to do the CTBT-trick of isolating India once more is bound to fail, if applied to cut-off negotiations. A cut-off provides India with much more leverage power than the CTBT. Of course, it all depends on the goals of a cut-off convention. At least in the perception of non-aligned countries, a cut-off convention is confined to bind India and to ban future production. Therefore, there is no compelling reason why non-aligned countries should press for cut-off negotiations and acquiesce in unsatisfactory results as they did in the case of a CTBT. They are convinced that the P5 - against the background of huge stock piles - have already more or less agreed to cease definitely the production of weapon-grade fissile material. Smaller nuclear weapon states will be persuaded by the United States to stick to this understanding, in the case of China, an internal P5 trade-off seems conceivable. Non-aligned countries in their capacity as non-nuclear weapon states parties to the NPT are not allowed to produce anyway, a cut-off treaty would only enhance this existing commitment. In this understanding cut-off negotiations would be superfluous for the vast majority of all states since more than 175 states have joined the NPT as non-nuclear weapon states and a simple arrangement among P5 countries as well as some bilateral arrangements with India would suffice. If the P5 insist on true multilateral cut-off negotiations, with no real interest of most countries in those negotiations, the fate of those negotiations will depend on India.

The conflict between the P5 and India as the major Non-NPT State, so long obscured in the context of the CTBT negotiations by internal P5 battles, would be obvious right form the beginning. In contrast to the CTBT where the scope had been a major internal P5 conflict, a P5 agreement on the limited scope of a future cut-off is already been taken for granted. Right from the beginning of negotiations the obvious question would be how to deal with India. But how to make India enter the NPT by the back door and implicitly abide by the NPT-rules, a treaty it has persistently been defying for the last 25 years? If they paid such a high price by resisting from joining the CTBT, why should they embark on treaty negotiations aimed at their commitment to the NPT system? India is not likely to get entangled once more into treaty negotiations it cannot control. In the CD context it will not allow any negotiation mandate to be adopted. Threatening India – and other reluctant states – by convening special cut-off negotiations outside Geneva based on the principle of majority vote will be perceived as an empty rhetorical gesture. If major countries want to convene a special cut-off conference elsewhere which is not governed by the principle of consensus, India simply will not participate. But what is the use of such a conference if the only reason for a cut-off convention consists in binding India? Being depicted as the essential major devil right from the beginning provides India with an enormous leverage power it did not have within the CTBT negotiations. And it would make use of this power.

To state the obvious, there will be no cut-off without prior agreement between the P5 and India. Almost certainly, India will once more put all its long-standing claims on the table such as a multilateral commitment to nuclear disarmament within a time-bound framework, an ad-hoc committee on nuclear disarmament, etc. we all know from other occasions. Certainly, India would raise the ante. We can rightly denounce those claims as misguided, exclusively brought forward to undermine the existing non proliferation logic in the framework of the NPT. All this is true, however, we have to compromise if we really want to negotiate a cut-off at the end of the day. In my personal opinion, it all boils down to the question whether the western nuclear weapon states and in particular the U.S. will accept India as their peer they have to negotiate with, without forcing India into the NPT-system (i.e. as a non-nuclear weapon state) as a prerequisite. Within the CTBT-negotiations, India was denied such a status. I do not share the prevailing point of view that India can be forced to accept the NPT and its corollary agreements such as the CTBT and a future cut-off.

Advice to future negotiators of a cut-off convention

If there will ever be cut-off negotiations:

- Make sure that a general agreement between India and the P5 has been found before embarking on treaty negotiations.
- Ask for discussion on possible trade-offs in this regard - Do not rely too much on P5 treaty management.
- Do not allow that basic conflicts about the scope and the purpose of the treaty be shifted to more technical treaty clauses such as the entry-into-force clause and dealt with in the last moment.
- Do not allow anybody to use the entry-into-force clause as a tool to single out a specific state which declared not to join the treaty. This was the major failure of the CTBT negotiations.

Appendix II: Euratom and other regional safeguards systems and their potential roles in a cutoff

It was Euratom[162] which had the initial responsibility of implementing safeguards in the territory of its member states, before IAEA verification was established. It was instituted by the Euratom Treaty signed in Rome in 1957 and is now an integral part of the European Union. The background was the intention of several West European states to establish civilian nuclear industries and, at the same time, a vital interest of some countries to control its exclusive civilian use in others, one of the targets being especially Germany whom the neighbours sought to prevent from acquiring nuclear weapons. The founding of Euratom took place in the framework of European integration that was aimed at preventing the recurrence of violent conflicts in Europe and at fostering the economic well-being of all member states. Euratom therefore has become a regional organization with the objective to promote civilian nuclear cooperation among its members and to assist them in fulfilling their nonproliferation goals and obligations. As a result, it has established and greatly enhanced mutual confidence and cooperation in the region. Its activities are thus closely related to the global nonproliferation regime.

In contrast to the IAEA, Euratom does not discriminate between NWS and NNWS which have identical obligations. Instead, it applies its safeguards similarly to the complete civilian nuclear fuel cycles of all members, including France and Britain. The term *"safeguards"* in the framework of the Euratom Treaty means the set of measures applied to enable the Commission to satisfy itself that nuclear material is not diverted from its intended and declared uses, which, although not specifically mentioned in the Treaty text, are exclusively civilian for NNWS. However, Article 84 of the Euratom Treaty includes a "defense clause" stating that safeguards do not extend to material for military use. Practically, this clause applies only to NWS or SON, since NNWS are bound by the NPT.[163] As a consequence, all nuclear material in NNWS is under Euratom safeguards while only the military nuclear material in NWS is under national authority. In dual-use facilities in France and Britain, control by Euratom or national authorities can vary with time depending on the declared use.

Euratom’s safeguards are more comprehensive and intrusive than those of the IAEA, and also its legal authority extends much further. The major difference is that IAEA safeguards are based on a contractual relation between parties, e.g. IAEA with a state or a group of states, while Euratom safeguards is equivalent to law directly applicable to operators without states having rights to interfere. This law is superior to national law because the states have renounced their sovereignty on nuclear control regulations in favour of Euratom. Under Art. 86 of the Treaty, the EU nominally owns all fissile material that has been produced or imported to the EU. Art. 87 gives persons and enterprises the possession of and unlimited rights to use fissile material. The operators are directly responsible to the Commission in respect of safeguards.[164] Euratom is authorized to receive accountancy information directly from the nuclear

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[162] D. A. Howlett, fn. 111; Commission of the European Communities, Report on the Operation of Euratom Safeguards 1991 - 1992, COM(94) 282 final, Brussels, July 1994; W. Gmelin, The role of Euratom in international safeguards, in: International Nuclear Safeguards 1994, Proc. of a symposium, Vienna, 14-18 March 1994, p. 49; S. Thorstensen, K. Chitumbo, Safeguards in the European Union: The New Partnership Approach, IAEA Bulletin, 1/1995.

[163] Meanwhile, there are no SON any more in the EU.

[164] The European Commission holds authority regarding initiative for legislation, regulation for implementation of legislation, and execution of the Treaty. Euratom is a Directorate within DG XVII (Energy). The

industry, without member governments being necessarily involved, and to instruct those companies as far as safeguards matters are concerned. Euratom safeguards apply earlier in the fuel cycle than those of the IAEA under the NPT: they start already with uranium ore. However, their objectives are mainly detection of inconsistencies in operator's accounts, and declared and real technical characteristics of a plant, and detection of diversions. Specific measures aimed at detection of undeclared activities like analysis of environmental radioactivity are not regularly applied. The member states are supposed to provide for the physical security of fissile material. However, these national systems have to be compatible with the Treaty's provisions. Euratom inspectors enjoy unlimited access rights. There are no visa problems and no constrained points of entry in member states. Inspectors designated by the Commission cannot be refused by national governments after an initial consultation. These authorities, again, surpass those which the NPT invests in the IAEA. However, while the IAEA has an advisory group, the Standing Advisory Group on Safeguards Implementation (SAGSI), that has developed and updates fixed safeguards criteria, Euratom is lacking comparable standards.

Finally, the Commission also has enforcement powers: if obligations in relation to safeguards are found not to be implemented in a satisfactory manner, the Commission may step in and issue either a warning, cancel certain privileges, like financial and technical support, replace certain persons at the facility with persons appointed by the Commission and the national authorities, or withdraw fissile materials. This also goes far beyond the legal authority of the IAEA. However, in most Euratom countries, safeguards information is routed to Euratom via governmental agencies – Germany being the most important exception. In the UK, for instance, the Department of Trade & Industry's safeguards office acts as interface with Euratom, although Euratom still has direct dealings with operators.[165]

The objectives of Euratom safeguards are twofold: one is the regional control of non-diversion, the other is the function of the SSAC. In the EU, this function has been overtaken by Euratom, so that EU members do not need national SSACs and have renounced the souvereignty of running them. Only physical protection is carried out by the national states.

On a practical level, the relationship between Euratom and the IAEA has been defined in cooperation agreements.[166] In contrast to INFCIRC/153, the agreement between Euratom NNWSs and the IAEA (INFCIRC/193) makes the distinction between sensitive (i.e. those dealing with HEU and Pu) and non-sensitive facilities. At sensitive facilities, there had been joint teams of inspectors from both agencies. At other facilities, the principle of observation was applied, and the IAEA only verified Euratom safeguards. The problem emerging from this agreement was a lot of unnecessary duplication. This has led to the New Partnership Appraoch (NPA) in April 1992 which has enhanced cooperation and effectiveness and reduced duplication of efforts.[167] A new agreement between the IAEA and Euratom incorporating the 93+2 reform is on the negotiation agenda.

Euratom could play an important role in the verification of an FMCT for several reasons:

European Court has the right to control the legal character of the activities and regulations issued under the Treaty. Its rulings bind all organs of the Union as well as the governments and citizens of member states.

[165] W. Walker, personal communication.

[166] The safeguards agreement between the Agency, Euratom, and the EU's NNWS; this agreement, INFCIRC/193, is modeled after the NPT-model safeguards agreement INFCIRC/153; the agreement with the EU, the UK, and the IAEA: INFICIRC/263; the agreement with the EU, France, and the IAEA: INFICIRC/290, and the partnership agreement of April 1992.

[167] S. Thorstensen, K. Chitumbo, Increased Cooperation Between the IAEA and Euratom – The New Partnership Approach, in: International Nuclear Safeguards 1994, Proc. of a symposium, Vienna, March 1994, p. 271-283.

- Since it covers already the complete civilian fuel cycles of France and Britain, additional IAEA verification of all levels of intrusiveness can be implemented at any time, similarly to that of the NNWS. No further technical efforts to implement a SSAC are necessary. The two existing voluntary offer agreements between Euratom, the IAEA, and France and Britain, respectively, might be replaced by new ones which would be more similar to INFCIRC/193.
- Since Euratom has also safeguarded dual-use facilities in both countries, simply the defense clause of the Euratom Treaty would not be applied any more to material production facilities which means that these facilities cannot be withdrawn any more from Euratom authority when the FMCT enters into force. The clause would still be applied to some storage sites and weapons factories as long as the possession of previously produced unsafeguarded material is still allowed. But it cannot be applied to reprocessing of spent fuel from the so far unsafeguarded Chapelcross and Celestin reactors, where tritium is produced (c.f. section 4.5.2 Tritium).
- The acceptance of Euratom safeguards in France and Britain might be higher than that of IAEA safeguards. These countries are used to work with Euratom since decades which has resulted in a high degree of confidence. It is noteworthy that for a long period, France was not member of the NPT but member of Euratom. An important role for the acceptance is also played by the only European nationalities of the inspectors.
- In case that the negotiated FMCT verification system should be less comprehensive than that of the NPT, Euratom’s (and potential other’s) more intrusive regional safeguards can at least constitute a supplement enhancing the international confidence.
- Because of the structurally stronger legal authority of Euratom and the Commission in comparison to that of the IAEA, any withdrawal or uncooperative behaviour is far less likely and is also much more deterred because it would disturb the European integration process as a whole. This would run counter many other interests of European countries, especially those of economic nature.
- The more verification tasks are assigned to regional safeguards, the lower are the additional costs that are needed for IAEA verification.

Another regional system is the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) which was established in 1991.[168] Similarly to Euratom, ABACC plays a twofold role: as safeguards and control agency that conducts inspections and verifies physical inventories, and in implementing a "Common System for Accounting and Control of Nuclear Materials" which serves as SSAC in order to enable IAEA verification. ABACC is another demonstration of the remarkably positive role that a regional system can play in nonproliferation: within a few years, the strong suspicion against the two countries has been replaced by confidence in their peaceful intentions. Initially, both countries rejected the NPT and full scope IAEA safeguards because they regarded them as discriminatory. ABACC safeguards in contrast were acceptable to both sides although they were former adversaries. As in the case of Euratom, inspectors from the region are more tolerated than IAEA inspectors, and similarly, the regional inspections have played an important role in enhancing mutual trust and in training practical cooperation. At the same time, it has become possible to set up a cooperation agreement with the IAEA that in practice is equivalent to INFCIRC/153.[169] ABACC therefore has

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[168] T. Zamora Collina, F. de Souza Barros, Transplanting Brazil and Argentina’s success, ISIS Report, Washington, February 1995; ABACC News, May/August 1996; J. Carasales, Argentina, Brazil, ABACC and the IAEA, PPNN International Seminar on Issues at the 1995 NPT Conference, Caracas, 3-6 May, 1994.

[169] The Quadripartite Agreement between Argentina, Brazil, ABACC, and the IAEA, signed December 21, 1991.

paved the way for the IAEA. The verification of the NPT and the Tlatelolco Treaty as it is taking place today is already containing all elements that would constitute the verification of an FMCT.

A similar role could be played by other future regional systems. Namely Asiatom has increasingly been discussed in the last years, and interests of the countries – especially Japan – in the region are visible.[170] These interests originate from their strong mutual mistrust and the fast pace of development of civilian nuclear industry. Especially Japan's large civilian plutonium recycling industry gives rise to concern of its neighbours, similarly China's nuclear capability, lacking transparency and rapid conventional arms built-up, and also the recent history with North Korea's attempt to proliferate. Euratom's successes in the creation of regional confidence, in the simultaneous enabling of the development of civilian nuclear industries and in limitating U.S. influence has motivated some East Asian governments and analysts to think of an analoguous system for East Asia. Such a system could be especially important for an FMCT since it would incorporate the NWS China whose nuclear fuel cycle and material is very opaque. As Euratom, also a potential Asiatom could implement safeguards in the civilian fuel cycles of all member states in a nondiscriminatory way. Similarly as for France and Britain, a defense clause could be allowed for the Chinese previously produced military material and nuclear weapons factories. China could be more interested to start with regional Asiatom safeguards than with the IAEA for several reasons: it would get more intrusive control and insight of Japan's nuclear activities than without such a system, it would benefit from technical cooperation, together with the other East Asians, it would have a stronger position in international nuclear matters, it would enhance regional confidence by setting up a credible SSAC system, it would have more direct influence to avoid proliferation cases like North Korea, and it would avoid Western, especially U.S. inspectors, since China is still hesitating to imagine such controls of its own nuclear activities. At the same time, cooperation between the IAEA and Asiatom could start and could gradually be enhanced, thereby strengthening the roles of both organisations.

For an FMCT, the development of an Asiatom would be beneficial for several reasons similar to those listed above for Euratom. Especially in case the role of the IAEA in NWS is initially limited, an Asiatom could take over verification tasks that are more acceptable if conducted by regional authorities rather than by the IAEA. At the same time, the path for the IAEA would be paved and the potential would be created that the IAEA's role might be extended in the longer run.

However, it is uncertain when and whether at all such a system might materialize, because in contrast to Europe where Euratom was founded with the much broader vision of European integration, a similarly strong vision and incentive is still lacking in East Asia. China has so far shown very little interest in Asiatom. The Japanese have great difficulty getting the Chinese to discuss it – most of the discussion has been with the Koreans (who are rather mistrustful of

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[170] R. A. Cossa (Ed.), Asia Pacific Multilateral Nuclear Safety and Non-Proliferation: Exploring the Possibilities, A Report from the International Working Group on Confidence and Security Building Measures organized by the Council for Security Cooperation in the Asia Pacific, Honolulu, Hawaii, December 1996; H. Kurihara, The role of nuclear energy and associated risks in the Asia-Pacific region, Paper prepared for the Meeting of the CSCAP Working Group on Confidence and Security Building Measures in the Asia Pacific, Washington, D.C. USA, May 1997; T. Suzuki, Nuclear Power in Asia: Issues and Implications of "ASIATOM"-Proposals, presented at the United Nations Kanazawa Symposium on Regional Cooperation in Northeast Asia, Kanazawa, June 2-5, 1997; R. A. Manning, Atoms for Peace and War, The Washington Quarterly, p. 217, Spring 1997. The various proposals vary substantially. For comparisons see especially Suzuki; and B. Roberts and Z. Davis in: Cossa, op. cit. Also the term *Pacificatom* is coming to be used, partly because India and other Asian countries are not involved.

Japan’s motives, suspecting that the main purpose is to legitimise waste sites outside Japan) and with ASEAN countries.[171]

There are also some proposals for regional safeguards systems in other regions, e.g. in South Asia, in the Middle East,[172] and in the former CIS and East Europe.[173] The latter would include the NWS Russia. The former would include India and Pakistan or Israel.[174] Comparable advantages could be listed also for those systems, however, their prospects to be realized are still remote. Their establishment is closely interrelated to security improvements in the respective region.

It is recommendable to reserve a role for regional safeguards systems in the verification of an FMCT. Some of them could start immediately after entry into force, namely Euratom could take over verification tasks in France and Britain and shift some of the burden from the IAEA budget. Others could take over tasks as soon as they come into existence, e.g. Asiatom. Flexibility in cooperation and task sharing between the IAEA and regional systems should be universally allowed and promoted, e.g. similarly in NNWs, NNWSs, and SON.

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[171] W. Walker, personal communication.

[172] Zamora et al., fn. 168.

[173] D. Fischer, Nuclear energy and nuclear safeguards in the CIS and East-Central Europe: The case for "Eurasiatom", The Nonproliferation Review, Spring-Summer 1994, p. 54.

[174] Israel is especially likely to have problems with intrusive verification. On the other hand it might be interested in some regional measures that enhance confidence and regional security. See S. Feldman, Nuclear Weapons and Arms Control in the Middle East, Cambridge, 1997, see p. 254f; G. M. Steinberg, Israel and the Changing Global Non-Proliferation Regime: The NPT Extension, CTBT and Fissile Cut-Off, Contemporary Security Policy, Vol. 16, No. 1, 1995, p. 70; A. Cohen, M. Miller, How To Think About – and Implement – Nuclear Arms Control in the Middle East, The Washington Quarterly, Vol. 16, no. 2, Spring 1993.

Appendix III: Glossary of technical and legal terms

Technical terms

Isotopes: Nuclides having the same number of protons but different numbers of neutrons. They have the same *chemical* properties but different *physical* properties. Example: Uranium-235 has 92 protons and 143 neutrons (mass number: 235 = 92 + 143), U-238 has 92 protons and 146 neutrons (mass number: 238 = 92 + 146). U-235 and U-238 are uranium isotopes. Many elements occuring in nature consist of *isotopic compositions*.

Fissile isotopes: Isotopes capable of undergoing fission by *interaction with slow neutrons*. Fissile isotopes are: U-235, U-233, Pu-239, Pu-241 (plutonium). They are also called ***fissile nuclides.***

Fissile material: Material containing fissile nuclides.

Fissionable isotopes: Isotopes or nuclides capable of undergoing fission by *any process*. An example is U-238 that is fissionable by very energetic neutrons (> 10 MeV). All fissile isotopes are fissionable, but not vice versa. They are also called fissionable nuclides.

Fissionable material: Material containing fissionable nuclides.

Natural uranium: Uranium occuring in nature consists of 99.3 % U-238 and 0.7 % U-235.

Enriched uranium: Uranium in which the concentration *of the isotope U-235* is greater than its natural value (> 0.7 %). A plant designed to enrich a specified isotope is called ***enrichment plant***.

Low enriched uranium (LEU): Uranium whose enrichment is below 20 %. Light water reactor fuel typically contains LEU enriched to 3% – 5%.

Highly enriched uranium (HEU): Uranium whose enrichment is above 20 %. A self-sustaining chain reaction, e.g. a *nuclear explosion,* is possible in HEU, but not possible in LEU. However, the higher the enrichment, the smaller is the mass necessary for the construction of one warhead. Nuclear weapon states typically use HEU enriched to about 93 – 98 %. The conversion of a plant designated for LEU production to HEU production is technically possible. Three applications of HEU are known: research reactors, naval fuel, and nuclear warheads.

Naval fuel: Fuel in use or intended for use in nuclear reactors for the drive of submarines. Normally, naval fuel is HEU. The enrichment varies between about 30% to over 90 %.

Depleted uranium: Uranium in which the concentration *of the isotope U-235* is lower than its natural value (< 0.7 %). It is a byproduct of uranium enrichment.

Uranium-233: Fissile isotope of uranium that does not occur in nature. It can be produced artificially from thorium by neutron irradiation in a nuclear reactor. This has never happened on a industrialized scale, but is principally another path for nuclear explosives as well as for nuclear energy.

Fertile material: A material, not itself fissile, that can be converted into a fissile material by irradiation in a reactor (by neutron capture). There are two basic fertile materials, U-238 and thorium-232. When these materials capture neutrons, they are partially converted into fissile Pu-239 and U-233, respectively.

Plutonium (Pu): A chemical element with the proton number 94. It has many isotopes and does not occur in nature. It is created by absorption of neutrons in U-238. This automatically happens in any running nuclear reactor when its fuel is containing uranium-238 which is exposed to the neutrons from the chain reaction. The Pu *isotopic composition* depends on the production process: when fuel stays in a reactor only very shortly, it contains mainly Pu-239. The longer it stays in the reactor, the larger becomes the content of the *higher isotopes*. In contrast to ordinary power reactors, fast breeders are capable of breeding Pu whose Pu-239 content is very high.

The following table gives an overview on common *plutonium classifications*:

Grade	*Isotope content*				
	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
Super-grade	—	0.98	0.02	—	—
Weapons-grade	0.00012	0.938	0.058	0.0035	0.00022
Reactor-grade	0.013	0.603	0.243	0.091	0.050
MOX-grade	0.019	0.404	0.321	0.178	0.078
Fast breeder blanket	—	0.96	0.04	—	—

from C. Mark

Nuclear weapon constructors prefer using Pu with a high Pu-239 content (*super-grade, weapons-grade*, or from a *fast breeder*), because it has technical advantages. The disadvantage of other compositions, e.g. *reactor-grade* Pu, are uncertainty of predicting the explosive yields, higher radioactivities, heating and others. It is therefore not being used in the five nuclear weapon states. However, it must be emphasized that a nuclear explosion is principally also possible with reactor-grade Pu. It therefore also poses a proliferation danger.[175]

Spent fuel: Typically a mixture of unfissioned fuel, *fission products* which are highly radioactive, and plutonium. (The composition depends on many technical factors. An exception is fuel from thorium reactors.)

Reprocessing: A technical process capable of extracting plutonium from spent fuel. It involves chemical processes and radiation protection technologies.

Tritium: An isotope of hydrogen with 1 proton and 2 neutrons. It is an important material for modern nuclear warheads, although crude explosive devices can be fabricated without tritium. Since it decays with a half life of 12.3 years, it must be replaced regularly in NWS. It can be produced by accelerators, by extraction from heavy water in heavy water reactors (e.g. Candus), or by irradiating Lithium-6 by neutrons in nuclear reactors.

Critical mass: The mass of fissile material, in which the neutron losses and the neutron production of a chain reaction just compensate (e.g. the assembly is just critical). It is 49 kg for a U-235 sphere without reflector and normal density (18.7 g/cm^3) and 11 kg for a Pu-239-sphere (density = 19.5 g/cm^3). The geometrical shape, the isotopic composition, the compression and reflectors greatly influence the critical mass.

Mass needed for one warhead: In addition to the parameters influencing the critical mass, the amount of material needed for one warhead is further affected by two factors: firstly, the fabrication process of the pits inevitably results in material losses. Secondly, the neutron production

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[175] E. Kankeleit et al., and C. Mark, see fn. 71.

in a chain reaction must be much higher than the neutron losses, not only just equal (e.g., the assmbly must be made overcritical) which implies a larger mass. In contrast, the significant quantity is a definition that compromises between the competing goals of a high verification confidence and reasonable costs (see next section). It is therefore only superficially related to the mass needed for one warhead. The following table gives a rough assessment of uranium masses per warhead: [176]

Name	**enrichment / %**	**critical mass of an unreflected sphere / kg with density factor**			**assessed minimum U mass per warhead / kg**		
					gun type	**implosion type**	
		1	**2**	**4**		**beginners**	**advanced**
Natural U	0.7	— fast chain reaction not possible —					
LEU	3-5						
HEU	20	1438	179	23	1000 - 2000 ?	200 - 500 ?	70 - 150 ?
HEU	50	231	27	3.4	150 - 300 ?	30 - 80 ?	8 - 22
HEU	80	79	10	1.3	50 - 100	16 - 40	4 - 8
HEU	90	62	8	1	35 - 80	9 - 20	3 - 7
HEU	100	49	6	0.8	25 - 60	7 - 15	1 - 5

The question marks are intended to indicate that the technical realization of such warheads is unlikely.

Legal terms[177]

Source material: Definition contained in the statute of the IAEA (Art. XX.3): "Uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine". Under [153] type safeguards, the term source material is interpreted as not applying to ore or ore residue, in particular to yellow cake, a concentrate consisting essentially of U_3O_8.

Special fissionable material: Definition contained in the statute of the IAEA (Art. XX.1): "Pu-239; U-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term 'special fissionable material' does not include source material."

Nuclear material: Definition contained in INFCIRC/153 para. 112, or INFCIRC/66 para. 77: Any *source material* or *special fissionable material.*

Direct-use material: Definition from the IAEA Safeguards Glossary 1987:[177] Nuclear material that can be used for the manufacture of nuclear explosives components without transmutation or further enrichment, such as Pu containing less than 80% Pu-238, HEU and U-233. Chemical compounds, mixtures of direct-use materials (e.g. MOX) and plutonium contained in spent nuclear fuel also fall into this category. Unirradiated direct-use material would require less processing time and effort than irradiated direct-use materal (contained in spent fuel).

Significant quantities: Definition by the IAEA meant as the approximate quantitiy of nuclear material in respect of which, taking into account any conversion process involved, the possibil-

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[176] A. Schaper, own calculation, method described in: Discussion of the parameters influencing the energy release of a hydronuclear explosion, draft 1996, to be published.

[177] For a comprehensive overview and more detailed definitions see: IAEA Safeguards Glossary, 1987 Edition, Vienna, 1987.

ity of manufacturing a nuclear explosive device cannot be excluded. The definition is contained in the following table: [177]

Material	**Significant quantity**	**Safeguards apply to**
Direct use material		
Pu[a]	8kg	Total element
U-233	8 kg	Total isotope
U (U-235 ≥ 20%)	25 kg	U-235 contained
Indirect-use material		
U (U-235 < 20%)[b]	75 kg	U-235 contained
Thorium	20 t	Total element

[a] For Pu containing less than 80 % Pu-238.

[b] Including natural and depleted uranium.

Safeguards terms [177]

Detection time: The maximum time that may elapse between diversion of nuclear material and its detection by IAEA safeguards; according to the current guidelines it should correspond in order of magnitude to conversion time.

Conversion time: The time required to convert different forms of nuclear material to the metallic components of a nuclear explosive device. Estimates range between order of days for direct use material, order of weeks for non-irradiated chemical compounds, of months for irradiated fuel and of one year for LEU, natural U, and thorium.

Detection probability: The probability, if diversion of a given amount of nuclear material has occurred, that verification activities will lead to detection.

False alarm probability: The probability that statistical analysis of accountancy data will indicate an amount of nuclear material missing that is larger than expected on the basis of measurement uncertainties when, in fact, no diversion has occurred. It is usually set at 5 % or less.

Physical protection: Measures for the protection of nuclear material or facilities designed to prevent unauthorized removal or sabotage. They may overlap with some safeguards measures such as containment and surveillance. Standards for materials in transit are set by the Convention on the Physical Protection of Nuclear Material.

State's system of accounting for and control of nuclear material (SSAC): Organizational arrangements on national level which may have inter alia, the following objectives:

- A national objective to account for and control nuclear material in the State and to contribute to the detection of possible losses or unauthorized use or removal of nuclear material (cf. physical protection).
- An international objective to provide the essential basis for the application of IAEA safeguards pursuant to the provisions of an agreement between the State and the IAEA. INFCIRC/153 safeguards require the maintenance of an SSAC. EU members have transferred the souvereignty of individual national SSACs to Euratom which is the EU's joint SSAC. It applies to the civilian nuclear fuel cycle of all members.

Appendix IV: Abbreviations

93+2	Name for the reform of the IAEA safeguards that is currently being implemented
AA	German Foreign Office
ABACC	Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials
ACDA	U.S. Arms Control and Disarmament Agency
APT	Accelerator-Produced Tritium
ASEAN	Association of South-East Asian Nations
AVLIS	atomic vapor laser isotope separation
CD	Conference on Disarmament
CTBT	Comprehensive Test Ban Treaty
CTR	Cooperative Threat Reduction
DG	General Directorate (of the European Commission)
DoD	U.S. Department of Defense
DoE	U.S. Department of Energy
EIF	entry into force
EMIS	electromagnetic isotope separation
EU	European Union
Euratom	European Atomic Energy Community
FMCT	Fissile Material Cutoff Treaty
FSU	Former Soviet Union
GMP	Guidelines for the Management of Plutonium
Gosatomnadzor	Russian Federal Inspectorate for Nuclear and Radiation Safety
HEU	highly enriched uranium
HSP	Hexapartite Safeguards Project
IAEA	International Atomic Energy Agency
INFCIRC	Information Circular of the IAEA
INFCIRC/66	model agreement between NWSs and the IAEA for voluntary safeguards
INFCIRC/153	model agreement between NNWSs and the IAEA for full scope safeguards
INFCIRC/193	agreement between Euratom, NNWSs, and the IAEA for full scope safeguards
MC&A	material control and accountancy
MINATOM	Russian Atomic Ministry
MLIS	molecular isotope separation
MOX	mixed oxide fuel
NAM	Non-aligned Movement
NNWS	non-nuclear weapon state that is member of the NPT
NPA	New Partnership Approach between Euratom and the IAEA (1992)
NP	nuclear nonproliferation
NPT	Nuclear Nonproliferation Treaty
NTM	national technical means
NWS	nuclear weapon state as defined in the NPT
P5	"permanent five", common denotation for the five NWS[178]
P8	Canada, France, Germany, Italy, Japan, Russia, UK, USA

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[178] This denotation is unfortunate, because it creates a linkage between the security council status and the NWS status, thereby contributing to incentives of acquiring or keeping such a status.

Pu	plutonium
PUREX	plutonium and uranium recovery by extraction
SAGSI	Standing Advisory Group on Safeguards Implementation
SON	state outside the NPT
SSAC	State’s System of Accounting for and Control of nuclear material
START	Strategic Arms Reduction Talks
STI	Safeguards, Transparency, and Irreversibility negotiations (between U.S. and Russia)
t	ton (Standard International unit)
UN	United Nations
UNGA	UN General Assembly
UNSCOM	UN Special Commission (for disarmament in Iraq)