

*Paper presented to the Annual Meeting of the Institute of Nuclear Materials Management,
Baltimore, Maryland, 11-15 July 2010*

PROPOSED FISSILE MATERIAL CUT-OFF TREATY: VERIFICATION ISSUES

John Carlson
Australian Safeguards and Non-Proliferation Office
RG Casey Bldg, John McEwen Crescent, Barton, ACT 0221, Australia

This paper presents the personal views of the author and not necessarily those of the Australian Government.

ABSTRACT

The purpose of the proposed Fissile Material Cut-off Treaty (FMCT) is to ban production of fissile material for nuclear weapons and other nuclear explosive devices. Verification aspects will be central to the FMCT, to provide assurance that: (a) fissile material production facilities are declared and fissile material produced at those facilities is not used for proscribed purposes; and (b) there is no undeclared production of fissile material.

Since the IAEA safeguards system is already a well-established verification system directly relevant to FMCT objectives, it makes sense to use this system rather than duplicate it. Further, doing so presents the opportunity to address some weaknesses in IAEA safeguards.

In addition to the technical aspects of verification, it will also be necessary to address institutional aspects: which will be the verification agency, what decision-making organs will be required, and so on.

1. INTRODUCTION

The Fissile Material Cut-off Treaty (FMCT) has the potential to deliver substantial security benefits, furthering the twin goals of nuclear disarmament and nuclear non-proliferation. By capping the amount of fissile material available for weapons use, the FMCT would be an essential step towards irreversible nuclear disarmament. A cut-off treaty would further tighten controls on fissile material, reducing the risk of fissile material leaking to proliferators or terrorists. The FMCT will complement the CTBT (Comprehensive Nuclear-Test-Ban Treaty). The CTBT impedes development of nuclear weapons by prohibiting testing – the FMCT will impose a quantitative limit on the amount of fissile material available for weapons use.

The negotiating mandate for the Conference on Disarmament (CD) specifies that the FMCT is to be:

“... a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices.”

Commencement of negotiation of the FMCT in the CD has been stalled since the negotiating mandate was agreed in 1995. In 2009 the CD agreed to commence negotiations this year (2010), but at the time of writing the CD remains at an impasse. The 2010 NPT Review Conference has reaffirmed the “urgent necessity” of negotiating and concluding the FMCT, resolved that the CD should immediately begin these negotiations, and invited the UN Secretary-General to convene a high-level meeting in September 2010 in support of the work of the CD. If commencement of negotiations in the CD continues to be blocked, other negotiation mechanisms are likely to be considered.

2. FMCT PROVISIONS

It is suggested that the basic provisions of the FMCT should be as follows:

1. A commitment by each party not to produce fissile material for nuclear weapons or other nuclear explosive devices;
2. Definitions relevant to the scope of the treaty, including the fissile materials that are the subject of the FMCT commitments, and a definition of *production*. The definitions might also clarify non-proscribed activities;
3. An entry-into-force (EIF) formula that establishes the date from which the commitment not to produce fissile material for nuclear weapons or explosive devices applies. The EIF formula would also specify the states that would have to join the treaty before it would take effect;
4. Provisions on the status of pre-existing stocks of fissile material, and possibly a parallel mechanism for states to declare all pre-existing fissile material and to voluntarily submit excess fissile stocks to irreversible peaceful use and verification commitments;
5. A commitment to negotiate/accept appropriate verification arrangements. The FMCT would set out the principal verification commitments. It is suggested that detailed verification provisions would be set out in IAEA safeguards agreements, modified as necessary – see section 4 below;
6. Institutional arrangements – including a general conference and an executive council (to be decided whether these would be specific to the FMCT, or would use IAEA organs – see section 5 below);
7. Institutional arrangements could include a mechanism for parties to review the operation of the FMCT at regular intervals;
8. Institutional arrangements could also include mechanisms for parties to bring to the attention of other parties issues of concern in relation to the operation of the FMCT – either in general or in the case of suspected non-compliance;
9. Provisions for settlement of disputes;
10. Provisions dealing with non-compliance – determination of non-compliance and reporting to the Security Council;
11. An amendment mechanism.

3. MATERIALS, FACILITIES AND ACTIVITIES SUBJECT TO THE FMCT

From the negotiating mandate, the basic FMCT commitment will be – not to produce fissile material for nuclear weapons or other nuclear explosive devices. Basic concepts to be defined include *fissile material*, *production*, and proscribed/non-proscribed activities.

Fissile material *Fissile material* is not a term formally used in current verification agreements. The fissile materials to be covered by the treaty should be those relevant to the manufacture of nuclear weapons. Broadly speaking, these are high enriched uranium (HEU) and plutonium. The materials regarded by the IAEA for safeguards purposes as *direct-use materials* – nuclear material that could be used for the manufacture of nuclear explosive devices without transmutation or further enrichment – are as follows:

- HEU, i.e. uranium enriched to 20% or more in the isotope U-235;
- plutonium containing less than 80% of the isotope Pu-238;
- uranium-233.

Plutonium cannot be used for nuclear explosive devices without first being separated from irradiated fuel or targets by reprocessing. It is suggested therefore that the treaty would apply to separated (unirradiated) plutonium.

The alternative, that the treaty would apply to all plutonium produced through irradiation after EIF, would require verification to apply to all reactors. This would increase the verification workload and cost very substantially, without commensurate benefit to the treaty objectives, since in any case plutonium could not be used for weapons without reprocessing.

Likewise, U-233, which is produced through irradiation of thorium, cannot be used for explosive purposes without being separated from thorium and fission products by reprocessing. So the form of U-233 defined as fissile material for the purposes of the FMCT would be separated U-233.

It is necessary to consider whether the FMCT should also cover other fissionable materials that could be used to produce nuclear weapons. The IAEA has identified neptunium and americium as *alternate nuclear materials* having potential proliferation significance. Of these, neptunium is the most significant, in terms of quantities potentially available in spent fuel and its suitability for explosive use. The IAEA's designation of americium as an alternate nuclear material was contentious at the time, due to major technical problems confronting explosive use of this material, but experts of some governments insisted that americium also has proliferation potential.

Based on this discussion, the following materials would be defined as *fissile material*:

- high enriched uranium;
- separated (unirradiated) plutonium;
- separated U-233;
- (possibly) separated neptunium;
- (possibly) separated americium.

The FMCT would apply to fissile material produced after the treaty's entry-into-force.

Production Production of fissile material, as defined above, requires three processes:

- to obtain HEU – uranium enrichment;
- to obtain separated plutonium – reprocessing;
- U-233 and *alternate nuclear materials* involve similar considerations to plutonium, i.e. these materials are produced through irradiation and are separated by reprocessing.

Thus, for the purposes of the treaty, it is suggested that *production* would mean high enrichment (isotopic separation) and reprocessing (separation of plutonium, U-233, and other elements as defined, from irradiated material).

It would also be necessary to apply verification to all fissile material subject to the treaty in downstream facilities, until the material ceases to be fissile material defined as being subject to the treaty, e.g. through irradiation.

Based on this discussion, the FMCT would apply to the following facilities:

- enrichment facilities (to confirm no undeclared high enrichment, and to account for any HEU produced);
- reprocessing facilities;

- downstream facilities – facilities in which HEU, separated plutonium, U-233, and (possibly) neptunium or americium subject to the treaty is processed, used or stored.

It is for further consideration whether verification would also need to apply to other facilities, see section 4 below.

Proscribed activities Proscribed activities would encompass production of fissile material after EIF for nuclear weapons or nuclear explosive devices. It follows that proscribed activities should include manufacture of a nuclear weapon or other nuclear explosive device using fissile material produced after EIF.

The presumption must be that any undeclared production of fissile material after EIF is for nuclear weapons. Accordingly, *proscribed activities* should include any undeclared production of fissile material after EIF.

Non-proscribed activities The FMCT would not proscribe production of fissile material *per se*, only production for nuclear weapons or nuclear explosives. Reprocessing for civil use would not be proscribed. Nor would production of HEU for civil use or for non-explosive military use (e.g. naval propulsion) – though consideration could be given to proscribing high enrichment (on the basis that existing HEU stocks should be sufficient for foreseeable needs) and separation of weapons grade plutonium.

A further non-proscribed use would be clean-up of military plutonium to remove americium build-up. Since this does not involve production of further stocks of fissile material (and in fact arises through decay of fissile material), clean-up is quite different to reprocessing and should be recognised accordingly. This aspect will need to be looked at in the definition of *production*. A complication will arise if americium is defined as a fissile material subject to the FMCT – in this case, americium recovered through clean-up of separated plutonium pre-existing the treaty would probably have to be exempted from the treaty.

Stocks Here, a fundamental question is whether the FMCT will apply only to material produced after EIF, or will also apply to material pre-dating the treaty. Many argue that the treaty should apply to pre-existing material – sometimes termed *stocks*. But there is nothing in the negotiating mandate to say that the treaty should be retroactive – a ban on production can only be forward-looking, applying to production that could occur after EIF. It is impossible to ban production that has already happened.

Furthermore, the nuclear-weapon states (NWS) have emphasised that they will not accept the retroactive application of this treaty – it is unrealistic to press for this.

Clearly however the question of stocks has to be addressed in some way – the benefit of the FMCT would be undermined if some parties take advantage of substantial pre-existing fissile material stocks to expand their nuclear arsenals. Parallel arrangements should be explored for transparency on fissile stocks, and for voluntary and irreversible submission of excess stocks to peaceful uses and verification. In future it can be expected that a further treaty(ies) dealing with stocks will be needed as nuclear disarmament is progressed.

4. VERIFICATION

The FMCT will require parties to conclude with the treaty's verification agency, an agreement setting out detailed arrangements for verifying the commitment in the treaty not to produce fissile material for explosive use.

There is an existing and well-established verification system, namely the IAEA safeguards system, which meets most of the verification objectives likely to be specified for the FMCT. The

IAEA safeguards system, which has been developed over some five decades, provides an ideal foundation for the FMCT's verification arrangements. It is pointless to re-invent the wheel. Without doubt the most efficient basis for FMCT verification is to build on existing safeguards agreements, supplementing and extending these agreements as necessary.

Every state with significant nuclear activities already has a safeguards agreement with the IAEA – albeit requiring, in the case of the NWS and non-NPT states, to be extended to ensure the coverage necessary to meet FMCT objectives.

Using the IAEA as the FMCT verification agency would not necessarily require that the IAEA would also be the executive authority for the treaty. If parties decide on a separate FMCT organisation, the IAEA could undertake verification activities on behalf of that organisation.

Basic verification concepts

Declared material and facilities Parties would declare to the IAEA all fissile material subject to the treaty and all relevant facilities – enrichment plants, reprocessing plants and downstream facilities handling fissile material subject to the treaty. IAEA inspectors would apply safeguards measures to verify that these declarations are correct.

Verification against undeclared production of fissile material Non-nuclear-weapon states (NNWS) party to the NPT are required to place all nuclear material under safeguards. An essential aspect of the comprehensive safeguards applying to these states is verification activities aimed at detection of possible undeclared nuclear material and activities, i.e. that states' declarations are complete. The additional protocol (AP) is required to enable safeguards to address effectively the possibility of undeclared nuclear material and activities.

Currently there is no such requirement for NWS and non-NPT parties, all of which have nuclear material outside safeguards (i.e. *undeclared* material). Under the FMCT these states will continue to have, outside safeguards, fissile material existing at the time of the treaty's EIF. However, it will be essential to have verification activities aimed at detecting any undeclared production of fissile material after EIF.

Verification scope, standards and intensity

This is an area requiring considerable development. In the case of horizontal proliferation, the diversion of relatively small quantities of fissile material will be enough for a NNWS to change its status to a nuclear-armed state. The scope and sensitivity of IAEA comprehensive safeguards – reflected in technical parameters such as goal quantities (e.g. the *significant quantity* of 8 kg plutonium), detection probability, timeliness goals, and inspection frequency – have been set accordingly.

For the states that have nuclear weapons, however, the calculus is rather different. These states will be concerned about treaty violations that are of sufficient scale to alter strategic relationships: for a state with *hundreds* of weapons, it might take a violation of hundreds of kilograms to be strategically significant. On the other hand, for a state with a small nuclear arsenal – and the objective of disarmament is that every NWS will progress to this situation in time – small-scale violations will be significant. One approach that would meet both these cases is to regard a breakout equivalent to say 1% of the monitored inventory as a strategic change.¹

For states with large arsenals and large fissile material stocks outside the scope of the treaty, it would make no sense to apply verification at facilities beyond those outlined above (enrichment, reprocessing, and downstream facilities). For states with smaller arsenals, verification, to be effective, may need to extend to a wider range of materials and facilities, e.g. low enriched UF₆ and irradiated low burnup plutonium.

These considerations are likely to be reflected in the development of a state-level approach for FMCT verification, building on experience being gained with the state-level approach in comprehensive safeguards. With a state-level approach, the technical verification objectives and parameters will be the same for all states, but decisions on verification intensity could take account of state-specific factors.

States with comprehensive safeguards agreements

As NNWS party to the NPT have already committed not to produce nuclear material for weapons purposes, and to accept IAEA safeguards to verify this commitment, no additional verification activities should be needed to verify NNWS commitments under the FMCT – provided these states have in force both a comprehensive safeguards agreement and an AP.

Other states – NWS and non-NPT parties

The principal effect of the FMCT – and its verification requirements – relates mainly to the NWS and the non-NPT states.

The NWS have safeguards agreements based on the same model as the NNWS (INFCIRC/153), except in the case of the NWS the agreements are “voluntary” and apply only to nuclear material in designated (“eligible”) facilities. The NWS would have to accept the commitment for safeguards to apply to all fissile material subject to the FMCT and all relevant facilities, and to designate material and facilities accordingly.

The non-NPT parties have IAEA safeguards agreements based on INFCIRC/66. These too could meet FMCT objectives if these states accepted the commitment for safeguards to apply to all subject fissile material and relevant facilities, and to designate material and facilities accordingly.

As already mentioned, the NWS and non-NPT parties would also have to accept verification aimed at providing assurance of the absence of undeclared nuclear material and activities – i.e. nuclear material and activities that are required to be declared under the FMCT.

This could be effected through the AP, but it will be essential to ensure that the provisions of each AP give the necessary coverage. All the NWS, and also India (but not currently Israel and Pakistan), have an AP, but for most of these the provisions fall short of what would be required for the FMCT. All the NWS and non-NPT parties would have to modify/conclude APs that provide the IAEA with the necessary information and access rights. Managed access, to protect sensitive locations, would be very important – and is already provided for under the AP.

An alternative to use of the AP might be the development of an equivalent instrument – maybe an FMCT protocol – tailored more specifically to the circumstances of the NWS and non-NPT states and their legitimate interest in protecting national security information. It should be noted this interest is shared by all parties – it is essential to ensure that verification activities do not result in leakage of proliferation-sensitive information.

Naval propulsion programs

This is a complicated issue for the FMCT, but it is also a potential issue under current comprehensive safeguards agreements. These agreements allow NNWS to remove from safeguards nuclear material intended for non-proscribed military use, under arrangements to be agreed with the IAEA. To date this provision has not been used in practice.

It should be pointed out that the need for verification of HEU in naval programs under the FMCT would arise only if there is further production of HEU after the treaty’s EIF. The

verification challenges would be avoided if the states concerned could conclude that current HEU stocks are sufficient to meet foreseeable needs without the need for further production.

The challenge for verification arises because states with naval reactors regard the design of naval fuel, and factors such as core loadings and range between refuelling, as highly classified. While concern about security is understandable, it is essential to develop appropriate verification arrangements so that naval programs don't present an opportunity for diversion.

Because of the sensitivities, verification for naval programs will require novel approaches. However, the problems are not insurmountable – the Trilateral Initiative between the US, Russia and the IAEA demonstrated the practicability of innovative approaches to verifying fissile material of sensitive composition, shape and mass. It may be possible to develop transparency and confidence-building arrangements that would complement formal verification.

Other issues

Irreversibility A concern with NPT safeguards agreements is that their duration is tied to the state remaining a party to the NPT. If the state withdraws from the NPT, the safeguards agreement lapses. The FMCT should contain an irreversibility provision, that once nuclear material and facilities become subject to non-explosive use and verification commitments they would retain this status in perpetuity.

Challenge inspections It is likely that a challenge inspection mechanism, which can be initiated by a party, will be required for the FMCT, either instead of, or as well as, the special inspections already provided for in safeguards agreements.

5. INSTITUTIONAL ASPECTS

The institutional arrangements for the FMCT will be an important focus for the treaty negotiations. These arrangements can be expected to include:

- Policy and decision-making organs – a general conference and an executive council;
- A mechanism for parties to review the operation of the FMCT at regular intervals;
- Mechanisms for parties to bring to the attention of all other parties issues of concern in relation to the operation of the FMCT – either in general or in the case of suspected non-compliance with FMCT commitments, including mechanisms for consultation on and clarification of concerns between states (either directly or through the verification agency);
- Provisions for settlement of disputes;
- Provisions dealing with non-compliance – determination of non-compliance and reporting to the Security Council.

A basic issue is whether a separate FMCT organisation is required, or whether FMCT functions could be added to the IAEA's responsibilities.

If – as suggested here – FMCT verification is based on IAEA safeguards, it follows that the IAEA safeguards inspectorate would be tasked with carrying out FMCT verification. The inspectorate could carry out this responsibility on behalf of an FMCT organisation. But if there is a separate FMCT organisation, this would raise a number of major issues – e.g. what would be the relationship between the IAEA Board of Governors and the FMCT executive body on questions of non-compliance?

To avoid these complications, and reduce costs, an alternative to a separate organisation would be to give the IAEA the mandate to exercise decision-making functions under the FMCT. This could be acceptable to the NWS, which are all permanent members of the IAEA Board of Governors. However, not all the non-NPT states are in this situation. For these states to accept that the Board should have this authority, no doubt it would be necessary to amend the Board's procedures to ensure they are able to participate in Board deliberations on FMCT matters.

6. ENTRY-INTO-FORCE

Four of the five NWS have had declared moratoria on production of fissile material for nuclear weapons in place for many years, and the fifth, China, is also understood to have ceased such production years ago. So in a practical sense the most urgent need for an FMCT is to avoid an arms race between India and Pakistan, each of which is ramping up fissile material production capability. This situation makes it a matter of particular concern that Pakistan is the state that has blocked commencement of FMCT negotiations.

Many states consider there is little point in having an FMCT unless India and Pakistan are parties. Accordingly they maintain the treaty's EIF formula should require these states (and Israel) to join before the treaty can enter into force. Other states look to the precedent of the CTBT, where a demanding EIF formula has resulted in lengthy delay and uncertainty in the commencement of that treaty, and argue against an unduly rigorous formula for the FMCT.

It is true that the greatest practical value of the FMCT at this stage would be to freeze fissile production by India and Pakistan. On the other hand, it is also the case that the FMCT is an essential step in progressing nuclear disarmament by all the nuclear-armed states, so the FMCT will be needed for the NWS in any event. The EIF formula is expected to be one of the most difficult aspects of the FMCT negotiations.

7. CONCLUSIONS

This paper has argued for the FMCT verification arrangements to be built on IAEA safeguards agreements and additional protocols. Developing the details of verification for the FMCT will require careful technical analysis of existing safeguards agreements and how they would need to be amended or supplemented to meet the technical objectives of the FMCT – it is suggested this work will be most effectively progressed in an expert working group rather than in the principal treaty negotiation.

Regarding the particular complications of verifying the naval fuel cycle, it would be an extremely valuable contribution, as part of the preparatory work for the FMCT, for experts from one or more NWS and other interested states to conduct a study of appropriate verification arrangements.

It is imperative to progress negotiation of the FMCT as soon as possible, to formalise the moratoria of those states that have ended production of fissile material for nuclear weapons and to avoid a dangerous arms race by those states that have not yet ceased such production. This paper outlines a practical approach for development of this treaty.

1. The 1% figure was informally adopted in the IAEA/US/Russia Trilateral Initiative.