Revised 9 July 2014

EFFECTIVE REGULATION OF URANIUM PRODUCTION AND EXPORTS WITH REGARD TO INTERNATIONAL OBLIGATIONS

An outline for state authorities and uranium producers

John Carlson

Counselor, Nuclear Threat Initiative

CONTENTS

OVERVIEW

- Uranium ore concentrate (UOC) has the lowest level of proliferation and security risk of all types of nuclear materials
  - for unauthorised acquisition of UOC to lead to production of nuclear weapons or explosive devices would require technical capabilities and infrastructure possessed by a relatively small number of states
  - UOC is a low specific activity material, so radiation risks are very low.
- Reflecting the low level of risk, international guidelines for security of UOC recommend only "prudent management practice".
- That being said, however, it is important to both government and industry to ensure appropriately robust controls to address the risks that do exist, including possible acquisition for non-peaceful nuclear programs, as well as to meet international obligations and to maintain public confidence in the way the industry is conducted.
- This paper outlines appropriate safeguards and security practices commensurate with the level of risk.

1. Introduction

1.a. Scope

These guidelines deal with non-proliferation and nuclear security aspects of uranium production and trade. In addition it is important to have effective regulation of environmental protection and occupational health and safety, but these are beyond the scope of this paper.

1.b. Interests and responsibilities of the state

The state has a legal obligation under a number of treaties and other international instruments to ensure effective regulation of uranium production and exports. These include the Nuclear Non-Proliferation Treaty (NPT), the state's safeguards agreement with the IAEA, the additional protocol to the safeguards agreement, the Convention on the Physical Protection of Nuclear Material (CPPNM), regional treaties such as the African Nuclear-Weapon-Free Zone Treaty and the Central Asian Nuclear-Weapon-Free Zone Treaty, UN Security Council Resolution 1540, and other relevant Security Council resolutions.

In addition to meeting international obligations, effective regulation of uranium production and export is essential for reasons of good governance – e.g. to protect the public and companies against theft and other criminal activities, to protect government revenue (e.g. royalties and taxes), and to maintain public confidence in the security and safety of the nuclear industry.

There are important reputational considerations – no state wants to be seen as failing in its international obligations, or having helped, even unwittingly, another state's efforts to acquire nuclear weapons.

1.c. Interests and responsibilities of industry

Clearly mining and milling operators and other industry entities are obliged to comply with the law, and to observe the regulatory requirements established by the state. But it is not simply a matter of legal compliance – industry has vital reasons of self-interest in maintaining effective control over its operations and property. Uranium is a valuable commodity – industry has a major commercial interest in protecting its property, including taking effective measures against theft of material and sabotage of facilities.

Maintaining public confidence in the nuclear industry is equally important to the industry as to the state – a major loss of public confidence could lead to the government imposing stricter conditions on industry, or even shutting down operations. Further, reputational risk is just as important to industry entities – failing to meet industry standards is not only embarrassing but could lead to commercial disadvantage, e.g. exclusion from particular markets or partnerships.

1.d. A shared responsibility

Effective regulation requires a partnership between the state and industry. The state needs to establish an appropriate regulatory framework, to ensure it is well understood by operators, and to encourage and monitor compliance – including where necessary through enforcement action. Operators need to appreciate that ensuring effective control over their facilities and

materials, through meeting regulatory requirements and through complementary activities such as training and equipping staff, serves their commercial interest.

Industry should establish policies, practices and procedures to develop a shared sense of corporate responsibility throughout each company. Quality management programs and the development of industry stewardship principles can make an important contribution. Especially important is the fostering of a security culture throughout uranium production and transport operations.

The state – as well as corporate headquarters – must ensure that operators receive sufficient funding (share of revenue) to cover the equipment, staffing and training costs necessary to meet their responsibilities.

The regulator should be an active participant in arrangements for peer review, experience-sharing, capacity building, training and support. Accordingly the regulator should ensure ongoing engagement with the IAEA (including the Division of Nuclear Security as well as the Department of Safeguards), the World Institute for Nuclear Security (WINS) and bilateral counterparts.

1.e. The regulatory framework

The basic requirements for an effective regulatory framework can be outlined as follows:

(a) a licensing system – mandating a licence to produce and possess uranium, specifying requirements and conditions to be met by licence holders, and establishing substantial penalties for unauthorized production or possession of uranium:

- to apply to all stages of uranium handling, e.g. production, transport and storage;
- should cover international obligations, e.g. provision of reports to the IAEA and facilitating access by IAEA inspectors;
- **NB** the IAEA's right to access and information under the state's safeguards agreement and additional protocol is not limited to licensed sites but could involve <u>any location</u> in the state in accordance with *complementary access* or *special inspection* provisions.

  Accordingly, it is essential for the state to ensure it has the necessary legal authority, through appropriate legislative provisions, to be able to facilitate a request by the IAEA for access or information not only for licensed sites but also for other locations;

(b) an independent regulator, together with appropriate accountability arrangements (e.g. to a Minister or to the legislature);

(c) effective security and accounting measures to be implemented by licence holders to protect against unauthorized access to or removal of uranium;

(d) inspection of licence holders by the regulator, including to confirm (c);

(e) an export approval process – licensing, customs inspections, etc.;

(f) enforcement provisions – including police powers and provision for criminal proceedings:

- for breaches of licence requirements, obstruction of inspectors, and unauthorized possession or production or of uranium;
- the regulator or other appropriate authorities should have a proactive program to detect possible unauthorized production or possession, and unauthorized exports.

Regulatory authorities should look for complementary mechanisms to cross-check information required for regulatory purposes, e.g. whether audits by taxation authorities can help to confirm uranium production levels, whether inspections by health and safety authorities or environmental protection authorities can help to confirm performance of security and accounting requirements.

It is important to conduct vulnerability assessments, to identify opportunities for unauthorized production, theft and unauthorized exports, on a periodic basis to ensure that licence requirements and inspection and enforcement activities are addressing the risks effectively.

In addition to the domestic arrangements outlined above, appropriate arrangements should be made to ensure that uranium remains under safeguards coverage after it is exported.

2. Definitions – what is the material covered by this paper?

This paper primarily addresses the product of uranium mining and milling – typically *uranium ore concentrate* (UOC), often called *yellowcake*. In most cases UOC comprises predominantly the compound U_3O_8, plus some impurities, though some processes produce other compounds, e.g. UO_4.

- The uranium content of U_3O_8 is 84.8 per cent.
- The uranium content of UO_4 is 78.8 per cent.

For high purity UOC, the U_3O_8 content (or content of other uranium compound such as UO_4) is over 99 per cent (i.e. impurities are less than one per cent).

The IAEA Statute and the NPT use the term *source material* – this includes *uranium containing the mixture of isotopes occurring in nature*, but does not include *ore or ore residue*. Source material also includes depleted uranium, and thorium.

Another commonly used term is *natural uranium* – uranium containing the mixture of isotopes occurring in nature. Natural uranium is encompassed by the definition of source material.

Where this paper uses the term "uranium", the term refers to uranium in the form of UOC, unless it appears from the context that another meaning is intended.

Thorium As noted, thorium is a source material. Unlike uranium, however, thorium cannot be used directly to produce nuclear energy. Thorium contains only trace amounts of fissile isotopes. The predominant thorium isotope, Th-232, is described as a *fertile* material, rather like U-238. The thorium fuel cycle requires initiation through use of additional fissile material. The cycle is based on transmutation of Th-232 to U-233 through neutron capture, and subsequent fissioning of the produced U-233. Currently there is limited demand for thorium, mainly for non-nuclear applications. Where thorium is present in an ore deposit, recovery might not be economic – in this case the IAEA may be interested in details of its disposal (i.e. in process waste) in case at some future time recovery does become attractive.

3. Identifying risks

3.a. Some basic facts and figures

For natural uranium, the IAEA *significant quantity* – the quantity for which the possibility of manufacturing a nuclear explosive device cannot be excluded – is **10 tonnes**. This applies whether the route to producing fissile material, starting with natural uranium, is enrichment (HEU) or irradiation (plutonium). A state with a clandestine nuclear program can be expected to seek to acquire natural uranium by hundreds or even thousands of tonnes – although such a state will be opportunistic, and buy what it can where it can, i.e. it may buy smaller quantities from several suppliers.

As already noted, the uranium content in pure UOC (as U_3O_8) is around 85 per cent. Thus 10 tonnes of natural uranium is approximately **12 tonnes of UOC**. This corresponds to approximately **30 standard (205 litre) drums**.[1] At a spot market price of $US50/lb U_3O_8[2] this quantity of UOC would be worth around **$US 1.32 million**, but on the black market it would be worth substantially more. At $US50/lb the spot market value of a single drum of UOC would be around **$US 44,000**.[3]

Thus UOC is a relatively compact, high-value commodity. Twelve tonnes, or 30 drums, would be easily carried on a medium-size truck. The usual packing of a standard shipping container is 40-45 drums, i.e. 16-18 tonnes – i.e. one shipping container can hold about 1½ *significant quantities*, with a commercial spot market value of around $2 million and a black market value many times this. UOC is a very attractive material to steal for those in a position to do so.

3.b. Risk scenarios

As discussed in the Introduction, a failure to exercise effective control over uranium could result in loss of public confidence in government and industry, and reputational damage for the company concerned.

The obvious risk is theft, or unauthorized removal, of UOC – from the mine/mill or during subsequent transport and storage. There is also the risk that uranium may be diverted from the approved route/destination after export, and delivered elsewhere. Another risk, which should not be excluded, is production from illicit mining and milling operations.

To provide an incentive for theft or other illegal acts, there must be a buyer for the uranium and it must be possible for the buyer to take possession. **Iran** is known to have sought uranium in contravention of Security Council resolutions. There may be other illicit buyers, e.g. the **DPRK** (North Korea) which has a nuclear weapons program and is also the subject of Security Council resolutions. More generally, uranium producers must counter the possibility that their uranium could end up in unsafeguarded nuclear programs – other states

1. A standard drum typically contains 400 kg of U_3O_8, comprising 340 kg U.
2. At the time of revising this paper (late June 2014) the spot market price was depressed, at around $US28/lb U_3O_8 (i.e. approx. $US62/kg). $US50/lb is considered a more representative medium-term figure.
3. For UOC as UO_4 (which has a slightly lower uranium content), these figures are slightly different: 10 tonnes of natural uranium is approximately 12.7 tonnes of UOC; corresponding to 32 drums. The content of a drum would be around 315 kg U.

currently producing fissile material for nuclear weapons are India, Pakistan and possibly Israel.

Thus the risks that the state should address by vulnerability assessments are:

(a) the possibility of theft or other illicit acquisition of uranium; and
(b) the illicit removal of this uranium from the state; or
(c) the diversion of uranium from the authorized destination after it has been exported from the state.

Theft covers a range of possibilities, such as:

(a) break-in to a mine/mill and removal of UOC by outsiders, without help by insiders;
(b) removal of UOC by outsiders with insider help;
(c) removal of UOC by insiders – this could involve a small number of individuals or potentially could involve collusion amongst a number of staff and even management.

Theft could be of UOC in filled drums (which would require use of lifting equipment and vehicles), or could be of bulk UOC – stolen before or during drum-filling, or removed from drums after they have been filled. Theft of bulk UOC is likely to involve smaller quantities, compared with drums, because of the practicalities of moving the material. Theft of small quantities will be more difficult to detect, and for this reason may be attractive to perpetrators. While small quantities might not seem attractive to illicit buyers, regular theft of small quantities could be significant over time (e.g. removal of 10 kg UOC every day will total one *significant quantity* in three years).

In the case of insider theft, one scenario is undeclared production – rather than stealing UOC that has been quantified and recorded on the facility inventory, where the risk of eventual detection may be high, the level of UOC production can be understated, with the undeclared excess being available for removal. This scenario implies collusion by a number of persons at the mine.

Theft could also occur after UOC has left the mine, i.e. in transport to a storage area or port, and while in storage. For drummed UOC, theft could involve whole drums, opening of drums and removal of some UOC, or even theft of entire shipping containers.

As already noted, unauthorized possession of UOC is not limited to theft. There is also the possibility of unauthorized mining and milling operations. In view of the infrastructure and capital required, such operations might not be considered likely, but the state needs to have a monitoring process for detection of unauthorized operations, to provide a deterrent against these.

3.c. Other uranium-bearing (or thorium-bearing) materials

Although this paper primarily addresses UOC, it is also essential for the state to exercise effective regulation of other materials containing trace, but extractable, quantities of uranium (and/or thorium), e.g. phosphates, mineral sands, monazite, tantalum concentrates, rare earths. As noted in the following section of this paper, the state is required to report to the IAEA on the export of any material containing uranium (or thorium) unless the export is for specifically non-nuclear purposes. The state must ensure effective control over the export of such materials, even though they are usually exported for purposes unrelated to nuclear use, to satisfy itself that the use really is not nuclear.

10.

4. International obligations

Under the NPT, parties have an obligation not to provide nuclear material, including *source material*, to any non-nuclear-weapon state unless the material is subject to IAEA safeguards.[4]

Reflecting the NPT, the IAEA comprehensive safeguards agreement[5] requires that when any material containing uranium (or thorium) which has not reached the composition and purity suitable for fuel fabrication of enrichment (the *starting point of safeguards*)[6] is directly or indirectly exported to a non-nuclear-weapon state, the exporting state shall inform the IAEA of its quantity, composition and destination, unless the material is exported for *specifically non-nuclear purposes*.[7] It is important to note this requirement is not limited to source material or UOC but applies to any material containing uranium or thorium (i.e. including ores and residues).

The IAEA operates a transit matching system to reconcile exports and imports, in an effort to detect unreported imports. The efficacy of this is dependent on the completeness of reporting by uranium exporters.

The non-application of the reporting requirement where uranium exports are said to be for non-nuclear purposes is potentially a serious loophole in safeguards reporting. The additional protocol[8] largely addresses this loophole by requiring the exporting state to report to the IAEA quantities, chemical composition and destination of exports of source material for non-nuclear purposes where these total 10 tonnes of uranium (or 20 tonnes of thorium), or more, to the same state in a year.[9] It should be noted that the loophole is not entirely covered by the additional protocol – the protocol requirement applies specifically to source material, rather than any material containing uranium or thorium.

The additional protocol addresses another gap in the comprehensive safeguards agreement, by requiring the state to report on holdings of source material before the starting point of safeguards exceeding 10 tonnes of uranium (or 20 tonnes of thorium), and allowing complementary access to the locations concerned.[10]

The Convention on the Physical Protection of Nuclear Material requires states to establish conditions which minimize the possibilities for unauthorized removal of nuclear material. The Convention sets out specific requirements for different categories of nuclear material, but in the case of natural uranium requires only that, as a minimum, *prudent management practice* should apply.[11]

4. NPT Article III.2. The NPT recognizes the US, Russia, UK, France and China as nuclear-weapon states. All other states are non-nuclear-weapon states.
5. IAEA document INFCIRC/153.
6. See INFCIRC/153 paragraph 34.(c).
7. INFCIRC/153 paragraph 34.(a).
8. INFCIRC/540.
9. INFCIRC/540 Article 2.a.(vi)(b).
10. INFCIRC/540 Articles 2.a.(vi)(a) and 4.a.(i).
11. Article 3.1.(a), Table.

The Central Asian Nuclear-Weapon-Free Zone Treaty obliges parties, inter alia, not to provide source material to any non-nuclear-weapon state, unless that state has concluded with the IAEA a comprehensive safeguards agreement and an additional protocol.[12]

Thus it can be seen that, although UOC is usually considered to be before the *starting point of safeguards*, a substantial range of international obligations applies to this material. The state is required to have in place a regulatory system and practices that will ensure the state exercises effective control over UOC and meets these various obligations.

12. Article 8 (c).

5. Regulatory framework

For a comprehensive discussion of what should be covered in a nuclear regulatory framework, the reader is referred to the following IAEA publications:

- *Handbook on Nuclear Law*;
- *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols*;[13]
- *Safeguards Implementation Guide for States with Small Quantities Protocols*.[14]

Attention is also drawn to the paper by the Asia-Pacific Safeguards Network on *Fundamentals and Good Practices of Safeguards Regulatory Authorities*.[15]

The following is an outline of points particularly relevant to the regulation of uranium production and export.

5.a. Licensing system

The laws of the state should provide that production and possession of uranium requires a licence or authorization by the regulatory authority. There should be substantial penalties for unauthorized production or possession of uranium.

The licensing system should require licence holders to perform measurements, maintain records, submit reports, apply security measures, and provide prior notice of transfers, as discussed in section 5.c below. Legislation and the licensing system should also require cooperation with inspectors from the regulatory authority (discussed in section 5.d below) and from the IAEA, e.g. facilitating access by inspectors to the licensed location, records, and relevant staff.

5.b. Independent regulator

It is essential that the regulatory authority is functionally independent. This means that decisions of the regulator must not be subject to interference from persons or entities involved in the promotion or development of uranium production and exports, including licence holders. There must be an effective separation between the functions of the regulator and those of any other person, body or organization concerned with the promotion or utilization of nuclear energy, including uranium production.

Ensuring regulatory independence is not simply a matter of the formal arrangements – legislation and so on. Also important are the resources available to the regulator. The regulator must have the technical capability – expert personnel etc. – to make the technical judgments necessary to undertake the regulator's responsibilities. An essential aspect of this is financial independence – the funding available to the regulator must be sufficient for the exercise of the regulator's responsibilities. Funding must be predictable and reliable, and not subject to undue control by external bodies.

5.c. Oversight of production, storage and transport by the operator

13. IAEA Services Series 21.
14. IAEA Services Series 22.
15. www.iaea.org/Publications/Documents/Infcircs/2013/infcirc845.pdf

The regulatory framework (legislation, regulations, etc.) should specify that it is the responsibility of the operator to ensure effective control over uranium that is in the operator's possession (i.e. uranium being produced, stored or transported, as the case may be). The operator should establish and maintain appropriate security and accounting measures to cover this uranium. These measures should be specified or approved by the regulator, using mechanisms such as regulations, licence conditions or orders.

In the case of mining and milling, although the principal material of interest in the context of this paper is UOC (included in the definition of *source material*), the requirement to report exports of any material containing uranium (unless specifically for non-nuclear purposes) means that the operator should have measures in place against unauthorized removal of material in process and wastes containing recoverable uranium.[16]

5.c.i. – accountancy system

The operator is responsible for maintaining an accountancy system that provides for the matters summarized in (i) to (v) following.

At a uranium mine/mill, the uranium being accounted for will comprise bulk uranium product prior to the drum filling area, and uranium contained in drums – in the latter case, provided the drums have been sealed (see section 5.c.ii), the uranium will be recorded for accounting purposes as items, i.e. drums (accounts will show the quantity of uranium in each drum). Likewise, after the uranium has left the mine/mill site in drums, it will be recorded as items.

Although the uranium is in the form of UOC, it is international nuclear accountancy practice to quantify it in terms of uranium element.

(i) **Inventory** A record should be maintained showing the inventory of uranium in the possession of the licence holder. The record should show the quantities of uranium on the inventory. It should identify all locations where uranium is present at the place covered by the licence, and enable the precise location of any particular batch or item on the inventory within a specified period.[17]

A physical inventory taking of uranium should be performed every 6 months.

Records should be retained for a period of 5 years and made available to inspectors on request.

(ii) **Inventory changes** The record should show all changes to the inventory – the quantities of all uranium received, produced, transferred, lost or otherwise removed from the inventory. An inventory change should be recorded on the inventory on the same day that it occurs.

(iii) **Measurements** Measurements should be performed to confirm the quantities of uranium on the inventory and the quantities involved in inventory changes. Measurements should be based on procedures, sample plans and equipment prescribed or approved by the regulator. The operator should determine the accuracy of measurements and estimate measurement uncertainties.

16. In Australia, for example, uranium licensing requirements apply to material with a uranium content greater than 50 per cent.
17. In Australia this period is two hours.

(iv) **Reports** The operator should submit reports to the regulator at prescribed times and/or intervals, setting out the inventory and inventory changes. Special reports should be submitted within the prescribed time for any unusual incident leading to a loss of uranium or indicating a possible breach of security.

The operator should give prior notice to the regulator, within the prescribed period, of proposed transfers from the operator's site, and proposed transfers out of the state (exports).

(v) **Cross-checking** of information for transferred uranium The accounting arrangements should include procedures for checking/authenticating documentation on uranium being transferred, e.g. from the mine to storage, from storage to loading on ship, etc. These arrangements should be adequate to counter possible falsification of documentation.

5.c.ii. – security (physical protection) arrangements

The basic objectives for the protection of UOC and associated infrastructure are:

- protection against theft (unauthorized removal);
- protection against sabotage;
- location and recovery of missing uranium.

These objectives are to be met by the application of prudent management practices by the operator (licence holder) which provide for, inter alia:

- timely detection and assessment of security-significant events;
- access delay, through use of fences, gates, building fabric or other barriers;
- initiation of an appropriate response within a specified time of the detection.[18]

The operator is responsible for maintaining and implementing a physical protection plan, approved by the regulator, reflecting these objectives and practices. The physical protection plan should clearly set out the activities to which it applies, and the roles, responsibilities and accountabilities of all personnel required to implement the plan.

The physical protection plan should be reviewed for effectiveness and efficiency on a regular basis, it is suggested at least every 3 years, or earlier as required to address changes in circumstances.

Key elements in the physical protection plan should include the following:

(i) access control to the site, and in particular to locations holding final product: protection of the site against intrusion – fencing, gates, monitoring and alarms, response plan, etc.;

(ii) a secure compound with access control for areas where UOC is produced and stored, and UOC drums are filled and stored;

(iii) drum filling operations to be monitored at all times (*two-person rule*, CCTV, etc.) – monitoring arrangements could include availability of CCTV data to inspectors through an electronic mailbox system or possibly data transmission;

18. In Australia this time is 10 minutes.

(iv) filled drums to be loaded into shipping containers as quickly as possible. Depending on how quickly this can be done, sealing drums with tamper-indicating devices should be considered;

(v) filled drums outside the drum filling area to be stored in a secure compound – drums to be stored in shipping containers, the containers are to be sealed and arranged in door-to-door configuration to impede unauthorized access;

(vi) vehicles and persons exiting the site to be monitored – including, if considered necessary, radiation monitoring;

(vii) procedures to determine the trustworthiness of personnel, transport drivers, etc.;

(viii) arrangements for tracking and protection of uranium being transported from the mine to other locations for interim storage;

(ix) arrangements for protection of uranium at storage locations;

(x) arrangements for protection of uranium being loaded on ships or other means of transport for export;

(xi) approval of shipping companies and routes.

The physical protection plan should incorporate a scalable threat model. The purpose of the scalable threat model is to establish a system of standardised physical protection measures for a wide range of security threats and their resultant risks to the production and handling of UOC. The scalable model's categories prescribe levels of physical protection measures to be implemented for each of the different levels of threat and resultant risks. The security threat level might be assessed as being: low; medium; high; or extreme. There should be scalable physical protection measures corresponding to these threat levels.

More details on the matters outlined here are at Annex A.

5.d. Oversight of operators by the regulator

The regulatory arrangements should provide for the right of inspectors (including IAEA inspectors) to have access to any locations necessary to verify, inter alia:

(i) location, quantity and composition of uranium, and consistency with the records;

(ii) consistency of reports with the records;

(iii) accuracy of measurement procedures and equipment;

(iv) information on the possible causes of material unaccounted for and shipper–receiver differences;

(v) information in special reports;

(vi) changes in the situation, e.g. design information.

Inspections should also be performed by the regulator to confirm that physical protection requirements are being met.

In addition to performance of inspections at appropriate intervals, the regulator should undertake some unannounced or short-notice inspections, and where appropriate should consider other verification measures such as remote monitoring (transmission of data to the regulator).

5.e. Export control

The state's regulatory arrangements should include effective customs procedures, to confirm the correct loading of uranium on ship (or other means of transport) for export – confirming the integrity of seals on containers, possibly a spot-check that containers have the stated number of drums, ensuring the containers are loaded on the correct vessel, etc.

An essential part of export control is to address the question, if uranium has been acquired illicitly, how could it be removed from the state? This requires not only that customs officials are aware of the various cargoes being handled at the principal commercial ports, but that there is an appropriate form of monitoring of minor ports and border crossings. It is essential to have full cooperation and information-sharing, including police intelligence and national intelligence information, between the regulator, the police, customs authorities, and other relevant national authorities.

5.f. Enforcement

The laws of the state should provide necessary powers for the regulator, inspectors, police, etc. to enforce compliance with legislation, licence requirements, and so on, including:

(i) right of access by inspectors to all areas of licenced sites and other locations as necessary to perform their responsibilities;

(ii) establishment of offences and penalties for violations, e.g. failures to report, refusal to provide information, obstruction of inspections, evasion of inspections or collection of samples, giving false or misleading information, unauthorized possession of uranium, theft, sabotage, threatening to misuse nuclear material, etc.;

(iii) authority for search and seizure, and arrest of individuals – including a requirement to obtain a warrant in appropriate circumstances;

(iv) authority to direct licence holders and others to take action to secure uranium;

(v) authority for national inspectors to facilitate the work of IAEA inspectors.

6. Ensuring uranium remains under safeguards coverage after export

This is a matter of international obligations, as outlined in section 4 above, as well as national policy on ensuring that exported uranium remains in peaceful use. In terms of international obligations, the minimum requirement is that a uranium exporting state:

- has a mechanism to limit exports to approved destinations;
- only approves destinations that are consistent with international obligations; and
- reports all exports to the IAEA.[19]

These steps alone, however, may not be enough. Further issues for the state to address include:

- how to ensure uranium is shipped to the approved destination and not elsewhere.

  This is pertinent both to ensuring effective performance of international obligations, and to national policy;

- how to ensure uranium is not retransferred from the receiving state to another state, contrary to the producer state's intentions.

  This is primarily a matter of national policy – the obligation to report retransfers to a third state to the IAEA rests with the receiving state rather than the producer state.

In addition to possible retransfers to third states, there are other matters the producer state may wish to determine, e.g.:

- whether after further processing its UOC may be highly enriched or reprocessed;
- in the case of supply to a nuclear-weapon state, ensuring the UOC and material derived from it remains in peaceful use; and
- ensuring internationally recommended security standards are applied to downstream materials.

6.a. IAEA safeguards and fungibility

Uranium is described as a *fungible* commodity, i.e. any kilogram of uranium element is equivalent to any other kilogram of uranium element (provided the enrichment level is the same). The principles of *equivalence* and *proportionality* are especially important where uranium from a number of sources may be mixed, e.g. in uranium conversion (processing of UOC to UF_6). In applying safeguards, the IAEA makes no attempt to differentiate between uranium from different states. The application of national "flags" or *obligations* is a matter for bilateral agreements.[20] As discussed in the following paragraphs, the purpose is to ensure that conditions required by the producer, but with which the IAEA does not concern itself, are met.

6.b. National safeguards and consent conditions

19. Strictly speaking there is no legal obligation to report UOC exports to a nuclear-weapon state. However, the IAEA needs information on such exports for the effective operation of its transit matching system for global uranium transfers, and has established the Voluntary Reporting Scheme for these exports.

20. See also John Carlson, *The role of bilateral nuclear safeguards agreements*, VERTIC, Trust & Verify, Issue Number 122, October 2005–February 2006, http://www.vertic.org/media/assets/TV122.pdf.

Conditions on retransfers to third states, high enrichment, reprocessing and security are not *safeguards* matters as such, but can be covered by *consent rights* in bilateral safeguards, or nuclear cooperation, agreements (i.e. the receiving state requires consent from the supplier state before undertaking such actions).

If a producer state allows sale into the international spot market without any additional requirements or arrangements, the state cannot be sure where the uranium will end up. There are various options for the state to gain assurance about the use of its uranium, as follows.

At the least, the producer state should require that the uranium be shipped directly to an established commercial converter such as in France or the US, where the uranium will subsequently become subject to the safeguards requirements of that state (or in the case of France[21], Euratom). Any subsequent transfer to a third state will be covered by the relevant US or Euratom nuclear cooperation agreements. This will ensure at least that a "peaceful uses" designation by the producer state will be given effect. The producer state's safeguards regulator should discuss with the regulator of the converter state (or Euratom) how to ensure arrangements of this kind work satisfactorily (e.g. it may be necessary for the two regulators to conclude an MOU providing for notice of shipments, etc).

However, delivery to these converters will not address the issue of consent rights for retransfers, high enrichment or reprocessing. In the first instance the producer state should look at the policies of the converter state, to see if they are consistent, or not, with the producer state's own policies. If there are no inconsistencies – e.g. the producer state has no objection to the range of states which the converter state supplies – then the producer state has no need to do anything more in this regard.

In addition to this practical approach of taking advantage of a converter state's (or Euratom's) nuclear cooperation agreements, the producer state should also look at taking advantage of commercial contract arrangements. The state can require the producer company to sell only to power utilities, not traders, and to include appropriate provisions in sales contracts. These could, e.g. specify that the uranium is for use by the utility exclusively for power generation and is not to be retransferred or on-sold without the consent of the responsible authority of the producer state. While contract provisions have no force in international law, a reputable power utility would not breach such a contract condition. Arrangements along these lines (i.e. shipment to an appropriate converter, together with appropriate contract provisions with the end user) would enable assurances to be given to the public that exported uranium remains in peaceful use.

6.c. Bilateral agreements

For a producer state wanting to ensure its uranium goes only to a state it approves, and to maintain the other consent rights discussed, the only sure mechanism for achieving this would be to establish bilateral nuclear cooperation agreements (and supporting *administrative arrangements*), along the lines of those of Australia, Canada, the US or Euratom, under which the producer state's consent is required for any retransfer, etc. Negotiation of such bilateral agreements and administrative arrangements, domestic ratification processes, and ongoing operation of the agreements will require considerable time and effort. For a relatively small producer, taking advantage of another state's (or Euratom's) bilateral agreements, together with appropriate contract provisions, will be more practical.

21. The UK also offered conversion services but has now largely phased out of these.

6.d. Central Asian Nuclear-Weapon-Free Zone Treaty

The situation is more complicated for the parties to this Treaty, which requires that uranium be supplied to non-nuclear-weapon states only if they have both a comprehensive safeguards agreement and an additional protocol.[22] Unfortunately to date none of the converter states mentioned above insists on an additional protocol for nuclear supply, including uranium retransfers. To meet this commitment in the Central Asian Treaty, producer states which are parties to the Treaty need a mechanism to exclude retransfer of uranium from the converter to a state without an additional protocol. Under current circumstances, the only mechanism for achieving this is by the producer establishing bilateral safeguards agreements requiring consent for retransfer, as outlined above.

6.e. Supply to India

A particular complication arises in the case of India, due to India's non-NPT status and the wording of the India/IAEA safeguards agreement.[23]

As noted in section 4 above, the NPT requires that NPT parties not supply nuclear material to any non-nuclear-weapon state unless subject to IAEA safeguards. The established international practice is to interpret this as requiring that any nuclear supply to a non-NPT state, such as India, must be subject to IAEA safeguards.

While an NPT party is obliged to ensure that nuclear material supplied to India is subject to safeguards, India, however, has no corresponding obligation. Under its safeguards with the IAEA, India is obliged to place imported uranium under IAEA safeguards only in two circumstances:

- if required to do so by a bilateral or multilateral arrangement to which it is a party; or
- if the nuclear material is processed or used in a safeguarded facility.

For a producing state just to report uranium exports to India to the IAEA will not be sufficient to ensure that the uranium is confined to India's safeguarded fuel cycle program. The producing state will need either:

(a) to conclude an appropriate bilateral arrangement with India requiring that supplied material will be subject to safeguards; or

(b) to take steps to ensure that the uranium will be used only in a safeguarded facility.

Regarding (a), it is not clear what kind of arrangement would suffice to meet the terms of the India/IAEA agreement. Clearly it would be preferable to have an arrangement that is legally binding, e.g. if not a formal agreement at least an exchange of legally binding diplomatic notes.

Relying on (b) would require that the uranium is not supplied directly to India, but through a third state that is in a position to ensure the uranium is used in a safeguarded facility. An example would be transfer of uranium to say the US for conversion, enrichment and fabrication into fuel assemblies which are then supplied to a safeguarded reactor.

---

22. The other existing nuclear-weapon-free zone treaties were drafted before the additional protocol was concluded, so do not include a similar provision.
23. Published as IAEA document INFCIRC/754.

To summarise − to be sure of meeting its NPT obligations, any state supplying uranium for use in India, if it does not have its own bilateral arrangement with India (preferably an agreement or legally binding diplomatic notes), should supply only through a third state that has such an agreement or appropriate arrangement.

ANNEX A

SUGGESTED PHYSICAL PROTECTION REQUIREMENTS FOR ACTIVITIES INVOLVING UOC

The following is an outline of best practice as applied by a major uranium producing state.

1. Physical Protection Objectives

1.1. The principles of *physical protection* are realised through personnel, procedures, physical structures, and equipment. The Licence Holder shall meet the following basic objectives for the protection of UOC and associated infrastructure:

1.1.1. Protection against theft;

1.1.2. Protection against sabotage; and

1.1.3. Location and recovery of missing material.

1.2. These objectives are to be met by the application of prudent management practices which shall include, but are not limited to: the application of detection with assessment; access delay; and, response measures. These three elements must be integrated to be effective as a system, and the system shall be tested regularly to verify its effectiveness.

1.3. Specifically, for the purpose of protecting UOC at uranium mines, the regulator requires, *inter alia*, that local arrangements be in place that will:

1.3.1. provide timely detection and acknowledgement of security significant events;

1.3.2. afford access delay with the use of fences, gates, building fabric or other barriers; and

1.3.3. initiate an appropriate response within 10 minutes of the detection.

1.4. It is preferred that any protective security equipment used be endorsed by [the state authority responsible for technical assessment of security-related equipment etc.].

1.5. Where individual criteria or requirements of this Appendix cannot be met, the regulator may accept alternate compensatory measures if they provide equivalent protection and are consistent with the Physical Protection Objectives. Such alternate measures shall be explicitly addressed in the Plan and must be approved by the regulator.

2. Scalable Threat Model - Scalable physical protection measures

2.1 The purpose of the scalable threat model is to establish a system of standardised *physical protection* measures for a wide range of security threats and their resultant risks to the production and subsequent handling of UOC. The scalable model's categories prescribe levels of *physical protection* measures that shall be implemented for each of the different levels of threat and resultant risks.

2.2 The Plan should include a scalable system of interim measures that collectively address changes in threat levels and their associated risks. These measures shall be capable of being implemented rapidly in response to an elevated threat, and for the

system to remain cost effective, it is desirable that the interim measures be readily discontinued.

2.3 Four security threat levels are described below [could be based on definitions by the state authority responsible for security assessment]. The regulator will notify the Licence Holder of the security threat level that applies at any given time.

2.3.1 LOW Threat Level.

2.3.2 MEDIUM Threat Level.

2.3.3 HIGH Threat Level.

2.3.4 EXTREME Threat Level.

2.4 The Licence Holder is required to provide sufficient *physical protection* measures to defend against the specified level of threat, which are specified in paragraphs 4 and 5 below.

3. Security Definitions

3.1 A *Central Alarm Station (CAS)* is an installation which provides for the complete and continuous alarm monitoring, assessment and communications with guards, facility management and the response/police forces.

3.2 The *Door-to-Door configuration* is the placement of shipping container(s) adjacent to each other such that the doors cannot be opened sufficiently to allow access into the container.

3.3 A *Secure Compound* is a compound protected by a barrier consisting of either a security fence or building fabric or other barrier, with access control; and

3.3.1 the presence of 24 hours security guard(s) or other authorised personnel; or

3.3.2 a perimeter intrusion detection system monitored by the site *Central Alarm Station* (using CCTV), or visual oversight from guard response; or

3.3.3 Video Motion Detection (VMD); or

3.3.4 a combination of the above.

For a secure compound, the following shall apply:

3.3.5 access control may be implemented by either an electronic access control system or mechanical locking approved by the regulator;

3.3.6 assessment and verification of alarm detection shall be achieved through CCTV or visual oversight by security guard(s) or other authorised personnel;

3.3.7 performance of cameras and monitors shall enable the assessment of a person or activity being monitored during day and night;

3.3.8 illumination of the area shall be maintained to a minimum performance of 5 Lux uniform, or otherwise to provide for effective visual assessment of persons or activities;

3.3.9 where mechanical locking is used, keys are to be strictly controlled by an appointed officer and secured when not in use;

3.3.10 access is to be restricted to authorised persons who require it; and

3.3.11 records are to be kept of electronic access control or the issue of keys.

4. LOW Threat Level Physical Protection Measures

This level of threat represents the baseline *physical protection* measures to be applied for the UOC process and functions under normal operating conditions.

4.1 **Centrifuge, Calciner/Dryer and Drum Filling area(s)**

4.1.1 This area (or areas) shall meet the requirements for a *secure compound*, but having **two** segregated barriers, each with access control (e.g. a building within a fenced compound);

4.1.2 drum filling activities shall at all times be monitored by authorised personnel or by CCTV camera monitoring; and

4.1.3 unsupervised drums of UOC shall be stored to detect and/or hinder unauthorised activities (e.g. by CCTV monitoring, mechanical locking, or otherwise).

4.2 **Precipitator and Product Thickener plant area(s)**

4.2.1 An access controlled area consisting of at least one physical barrier (security fence, building fabric or otherwise) shall be used to restrict access to authorised persons only;

4.2.2 access to UOC product thickener plant sample points/taps shall be controlled to either detect and/or hinder unauthorised activities (e.g. by monitoring, mechanical locking, or otherwise); and

4.2.3 UOC is not to be stockpiled or stored outside of the processing plant system without the written authority of the regulator and only if an appropriate level of *physical protection* is applied to this material.

4.3 **UOC Storage Compounds**

4.3.1 Drums containing UOC stored outside the drum filling area shall be secured in shipping containers in *secure compounds*.

4.3.2 Preferably, sealed containers will be placed in the compound(s) in *door-to-door configuration* or otherwise arranged to prevent the opening of container doors; or, if this is not operationally practical, the containers shall be positioned to enable detection of attempts at unauthorised access to the container doors.

4.4 **UOC sample storage**

4.4.1 UOC or other in-process uranium, as samples, shall be securely stored in access controlled areas to either detect and/or hinder unauthorised activities (e.g. by CCTV monitoring, mechanical locking, or otherwise); and

4.4.2 records are to be kept of electronic access control or the issue of keys.

4.5 **Security fences, gates and barriers**

Security fences and gates shall be built to [defined standards] and provide the following performance:

4.5.1 fences shall be a minimum of 2.4 metres in height from ground level and include anti-climb measures;

4.5.2 mounting of the fence fabric shall mitigate against access under the fence, or passage through anti-climb measures;

4.5.3 installation of structures or placement of items shall not be closer than 2 metres of the perimeter of the fence or gate. Where existing infrastructure

forms a climbing aid, or is within 2 meters of the perimeter of the fence or gate, compensatory measures shall be installed;

4.5.4 gates and other barriers shall provide at least the same level of protection as provided by the fence. Power operated gates should have manual override and/or emergency power-back-up features;

4.5.5 all fences, gates and barriers shall be inspected frequently, maintained in good repair and kept free of equipment, structures or materials that could aid unauthorised ingress; and

4.5.6 main entry gates shall be overlooked by staffed guarding posts, or monitored CCTV; or otherwise secured if unattended.

4.6 **Packing**

4.6.1 UOC shall be packed in IP-1 205 litre open-head mild steel drums, or other packaging as approved by the regulator.

4.6.2 For shipment, sealed drums shall be loaded into standard ISO 20 or 30 tonne rated, 20 foot ISO shipping containers.

4.6.3 Each container shall be fitted with locks or container seals of a type approved by the regulator; but once final checks have been completed, consecutively numbered container seals shall be applied.

4.7 **Transport of UOC by Rail and/or Road**

The following measures shall be applied for transport of UOC by rail and/or road**:**

4.7.1 transportation of UOC only along routes approved by the regulator*;*

4.7.2 inspection of all containers and seals to confirm that they are in an acceptable condition for transportation, and record the results of these inspections;

4.7.3 procedures to maintain adequate *physical protection* in the event of an accident or vehicle breakdown during transport; road vehicle/locomotive drivers shall be trained in these procedures;

4.7.4 procedures to provide for a timely and effective response in the event that theft, loss or unauthorised handling of the UOC occurring during transport; road vehicle/locomotive drivers shall be trained in these procedures;

4.7.5 checks to confirm that appropriate road vehicle/locomotive communication equipment is in good operational condition so that communication with the consignor and with local security/police forces is assured at all times;

4.7.6 instructions to road vehicle/locomotive drivers to deliver the consignment only to the destination Approved Locations;

4.7.7 instructions to road vehicle/locomotive drivers to observe all procedures and directions given by the Licence Holder prior to, and during, the transfer;

4.7.8 activation of emergency response procedures should a loss of communications occur; the regulator shall be informed of any escalated incident and duly advised of the outcome of any such incident;

4.7.9 fitting to any vehicles/locomotive transporting UOC in containers appropriate equipment to enable communication at all times with the consignor, transporter, local police, emergency services and mine site security staff. Dual redundant communications systems shall be in place (e.g. one system may be GPS communications);

4.7.10 for single vehicle transport, procedures to detect the interruption of the transport or deviation from the set route. To this end, state-of-health reporting between the consignor, transporter or mine site security staff shall

be established at no longer than 15 minute intervals. This may be achieved with appropriately tracked GPS communications; and

4.7.11 when more than one road vehicle is used to transport UOC in containers, travelling in loose convoy (i.e. keeping visual contact between each vehicle) with each vehicle fitted with appropriate equipment to enable two-way communication between vehicles at all times.

4.8 **Transport of UOC by Sea**

The following measures shall be applied for transport of UOC by sea**:**

4.8.1 transportation of UOC only in vessel(s) and along routes and to destinations approved by the regulator;

4.8.2 transportation of UOC only in accordance with the transport schedule provided to, and approved by the regulator;

4.8.3 keeping the regulator and the captain of the vessel informed of elevated risks the Licence Holder knows may affect the security of the vessel along the approved route and of the appropriate precautions being undertaken to manage the situation; and

4.8.4 arranging an *agent* for each port of loading and unloading, including trans-shipment, to provide oversight of the containers. The *agent* shall check that the integrity of the containers and seals and report the result of such checks to the regulator.

4.9 **Emergency Storage**

If it is not possible for any reason to unload containers at intended destinations, the containers shall be:

4.9.1 delivered to a *secure compound* approved by the regulator with containers placed in *door-to-door configuration*; or

4.9.2 if a *secure compound* is not readily accessible:

4.9.2.1 delivered to a compound that maximally matches the criteria for a *secure compound*; or

4.9.2.2 placed where the containers can be under constant guard; or

4.9.2.3 otherwise secured in consultation with the regulator; and

4.9.2.4 arrangements put in place to move the containers to a *secure compound* as soon as possible.

4.10 **Maintenance, Testing and Inspection**

4.10.1 The Licence Holder shall ensure all security related equipment is inspected and maintained to ensure its continued effectiveness.

4.10.2 Performance of the security system shall be periodically tested to ensure its continued effectiveness.

4.10.3 Should security deficiencies be identified, the Licence Holder shall ensure that corrective actions are taken.

4.11 **Staff, Subcontractors and Visitors**

The Licence Holder shall ensure that:

4.11.1 all staff or *subcontractors* in access controlled areas carry, produce on demand, and preferably display security passes or other valid site-issued identification;

4.11.2 site security staff are informed immediately of staff or *subcontractors* no longer requiring access to controlled areas (e.g. due to resignation or

completion of contract) to ensure that security passes are returned and access privileges are revoked;

4.11.3 visitors within controlled areas are escorted at all times and are issued with a current visitor's pass which shall be recovered following completion of the visit; and

4.11.4 a contact reporting scheme is in place for staff and *subcontractors* to report approaches by any person inappropriately seeking information of a security sensitive nature.

4.12 **Security Records**

4.12.1 The Licence Holder shall ensure that security related records associated with the operation of the security monitoring system are maintained and made available to the regulator or an *inspector* on request.

4.12.2 All electronic access control records, event-triggered CCTV images of alarm events (excluding those triggered from authorised access), alarm event and response logs, security maintenance records, paper based records (e.g. sign in/sign out records, security patrol and security incident logs) etc., are to be held for a minimum of 12 months.

4.12.3 Continuous CCTV recordings are to be held for a minimum of 30 days.

4.13 **Networked Information Technology Systems**

The Licence Holder shall ensure the following functions are enabled for any networked information technology (IT) systems used to protect processes and information on production and transport of UOC:

4.13.1 the recording of network logon attempts;

4.13.2 protocols in place requiring human resource managers to inform the IT managers of all staff and *subcontractor* separations allowing timely disabling of the ex-staff member's IT network account. In the case of adversely terminated personnel this process shall receive immediate action; and

4.13.3 a password management system that; forces a minimum password length, forces staff to regularly change passwords, locks terminals after a number of failed password attempts, and locks terminals after a period of computer inactivity.

4.14 **Subcontracting or outsourcing security activities involving UOC**

If the Licence Holder is *subcontracting* a security function to a person who is not another Licence Holder, the Licence Holder's security requirements are to be identified and included in the contract. These contracts, where relevant, shall provide for:

4.14.1 written confidentiality agreements between the *subcontractor* and the Licence Holder; and

4.14.2 security performance indicators/reports, subject to review, for contracts terms greater than 2 years.

5. Elevated Threat Level Requirements

In addition to baseline security measure applicable at LOW threat level, the following requirements apply at elevated threat levels. Further to the measures stipulated below the Licence Holder may also propose additional measures at MEDIUM and HIGH levels:

5.1 **MEDIUM Level:** This level applies when attack against the Licence Holder's infrastructure or activities is assessed as **feasible and could well occur**. This level can be issued by the regulator, or on the advice of [police or the state's security authority]. It is possible that once this level is implemented it may remain for several years. The following treatment measures shall be implemented:

5.1.1 maintain all LOW level requirements;

5.1.2 provide constant GPS tracking of all UOC rail/road transports;

5.1.3 increased guard presence at storage sites to allow regular site patrols and effective monitoring of security systems whilst retaining timely assessment of alarm events;

5.1.4 increased liaison with local police;

5.1.5 increased oversight of staff and *subcontractor* activities associated with the UOC process; and

5.1.6 increased on-site staff and *subcontractor* security awareness and vigilance;

5.2 **HIGH level:** This level applies when an attack against the Licence Holder's infrastructure or activities is assessed as **likely**. This level can be issued by the regulator after consultation with police or the state's security authority. It is possible that once this level is reached it may remain up to 12 months. The following treatment measures shall be implemented:

5.2.1 maintain all LOW and MEDIUM level recommendations;

5.2.2 road transport to have an armed escort, with guard presence at loading and unloading of shipping containers;

5.2.3 increased access control, entry checks, including to vehicles allowed on-site;

5.2.4 increased patrols where UOC is stored during operational hours; or full time guarding of UOC during non-operational hours; and

5.2.5 in consultation with the regulator and police, develop and identify, where possible, alternate storage areas and alternate road transport routes that provide a higher degree of assurance for safety and security.

5.3 **EXTREME level:** This level of security applies when attack against the Licence Holder's infrastructure or activities is assessed as **imminent**. At this level there is credible specific intelligence of planned sabotage or theft of UOC. This level can be issued by the regulator only after consultation with police and/or the state's security authority. It is expected that this level would be applied for short periods (e.g. 30 days or until the threat is dealt with). The following measures shall apply:

5.3.1 all movements of UOC are to cease. UOC is to remain in *secure compounds*. Loaded containers are to remain in the sealed condition and placed in *door-to-door configuration*. Individual drums that are not loaded are to be loaded into containers and locked, and these containers are to be placed in *door-to-door configuration*;

5.3.2 UOC shipments in transit when this level is raised are to proceed to the nearest approved *secure compound* and unloaded, however it may be deemed necessary to take the shipment to a more secure location if required by the regulator. The regulator will determine if an armed escort is required;

5.3.3 the Licence Holder will be briefed by the regulator on the situation, with the continued production or handling of UOC at the Approved Location, remaining the decision of the Licence Holder;

5.3.4 the Licence Holder will continuously monitor the location and quantity of all UOC in its control and immediately notify the regulator of any changes; and

5.3.5 if the specific intent of the threat is understood at the time, risk reduction measures may require flexibility to obtain the best outcome. This will require continuous liaison and cooperation with the regulator, and potentially other stakeholder agencies and law enforcement bodies.

The author

John Carlson is Counselor to the Nuclear Threat Initiative.

He was Director General of the Australian Safeguards and Non-Proliferation Office (ASNO) from 1989 to 2010. Other appointments included Alternate Governor of the IAEA's Board of Governors, Chairman of the IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI) 2001-06, founding Chair of the Asia-Pacific Safeguards Network, and Australian Sherpa to the 2010 Nuclear Security Summit.

The author acknowledges the assistance of ASNO staff in preparing these guidelines, and also the support of NTI. Responsibility for the content however is his own.