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IAEA SAFEGUARDS AND CLASSIFIED MATERIALS

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I. Introduction

The international community in the post-Cold War period has suggested that the International Atomic Energy Agency (IAEA) utilize its expertise in support of the arms control and disarmament process in unprecedented ways. The pledges of the US and Russian presidents to place excess defense materials, some of which are classified, under some type of international inspections raises the prospect of using IAEA safeguards approaches for monitoring classified materials. A traditional safeguards approach, based on nuclear material accountancy, would seem unavoidably to reveal classified information. However, further analysis of the IAEA's safeguards approaches is warranted in order to understand fully the scope and nature of any problems. The issues are complex and difficult, and it is expected that common technical understandings will be essential for their resolution. Accordingly, this paper examines and compares traditional safeguards item accounting of fuel at a nuclear power station (especially spent fuel) with the challenges presented by inspections of classified materials. This analysis is intended to delineate more clearly the problems as well as reveal possible approaches, techniques, and technologies that could allow the adaptation of safeguards to the unprecedented task of inspecting classified materials. It is also hoped that a discussion of these issues can advance ongoing political-technical debates on international inspections of excess classified materials.

II. Traditional Safeguards

Is it possible to utilize traditional safeguards approaches to verify declarations regarding excess defense materials in classified or sensitive forms? Traditional safeguards are based on materials control and accountancy (MC&A) and containment and surveillance (C/S).[1,2] C/S techniques do not appear to pose insurmountable implementation problems, although significant engineering challenges must be solved before they can be used in this new arena. Materials accountancy does pose substantial, perhaps insurmountable, difficulties. At bulk processing plants, safeguards declarations are verified through MC&A methods involving destructive analysis (DA) and nondestructive assay (NDA) measurements to provide quantitatively accurate, mass-based verification of nuclear material. Such measurements are not acceptable for excess defense materials in sensitive forms because they would reveal classified information. At civil facilities, where items are identifiable but the exact isotopics and quantities of nuclear material cannot be determined (e.g., at nuclear reactors), safeguards are based on item accounting and attributes measurements that provide gross defect verification of the items. This item accounting aspect of MC&A for international safeguards is not dismissable *a priori* as a potential tool for verifying declarations concerning items that contain classified or sensitive information.

In the context, an examination of item accountancy at nuclear power stations with particular attention to spent fuel assemblies may be useful. The nuclear material content (uranium and plutonium) of fuel assemblies is not conserved or readily measurable following irradiation, but the integrity of the fuel assemblies is maintained and safeguarding is accomplished by item accountability, containment/ surveillance, and verification of attributes such as the radiation signatures of spent fuel assemblies.[3] The nuclear power station is of significant nuclear safeguards interest because reactors produce large plutonium inventories, and these inventories are stored in the spent fuel cooling ponds at reactor facilities for long periods of time (up to tens of years).

At light water reactor nuclear power stations, verification of nuclear materials involves the following.[3–5] Nuclear reactor fuel assemblies are packaged as discrete, identifiable items, and reactors are classified as "item facilities for safeguards inspections since the integrity of the fuel is preserved during their presence in the plant."[3] Safeguards inspectors identify and count fuel assemblies, and also verify the composition of fresh fuel by nondestructive measurements. NDA measurements to verify the uranium and plutonium in fuel discharged from a reactor are generally not practical due to the intense fission product radiation in the spent fuel. As spent fuel is removed from the reactor vessel and transferred to the storage pond, a map giving the grid location of each assembly is made. In the storage pond, as in the reactor vessel, the assemblies are located under about ten meters of water. During a physical inventory, the inspector verifies with binoculars that the spent-fuel assemblies are in their proper locations. Also, surveillance cameras (film or video) and radiation monitors are installed inside the spent-fuel bay to record the movement of cranes, fuel assemblies, spent-fuel casks, and the entrance and exit doors. The surveillance pictures are reviewed by the inspector to verify that the station's record of activities since the past inspection is as declared. The surveillance cameras and monitoring information provide continuity-of-knowledge that assures the authenticity of the assemblies in the spent-fuel pond and reduces the effort required to complete an inspection. If the surveillance equipment fails, the integrity of the fuel assemblies in the pond must be reestablished. This is done by visual verification of all the assemblies along with attribute checks of spent fuel signatures on selected assemblies using, for example, the Cerenkov glow or a measure of neutron and gamma radiation. Reactor fuel assemblies generally remain in the same physical form during their entire residence time at the power station. They arrive at the power station in the form of fuel assemblies, reside in the reactor core as fuel assemblies, and are stored in the spent-fuel pond as fuel assemblies. The integrity of the assemblies is therefore maintained. Although knowledge obtainable on the nuclear material content of spent assemblies is intrinsically limited, continuity-of-knowledge based on item accounting can be maintained for fuel assemblies from fabrication, through reactor operations, and into spent fuel storage.

Although IAEA records include inventories of plutonium in spent fuel, such listings are largely based on unverified operator data, and the verification of this important but unmeasured stock of material is, in realistic terms, dependent on item accounting and related assurances of integrity. This example illustrates that not all traditional safeguards approaches are in all cases based on independently verified measurements of the quantity of nuclear material under safeguards. Accordingly, there is no reason to rule out approaches to the monitoring of items containing materials in classified forms simply on the grounds that the IAEA would be unable to quantify the material contained within those items.

III. Verification of Sensitive Materials

Unlike current applications of safeguards, there are no established approaches to the verification of classified or sensitive materials (e.g., nuclear-weapon components) arising from nuclear arms reductions and dismantlement. It is clear that NDA or DA, as applied in traditional safeguards for bulk processing plants, cannot be used because they would reveal classified information. Does traditional item accountancy offer a different view? Item accountancy requires continuity-of-knowledge through C/S and inspections, along with selected measurements of attribute signatures (gross defect) to provide confidence that the items under inspection have attributes of, or are consistent with, the declared materials. Item accountancy requires the ability to verify and re-verify the items (e.g., through item counting, identification of serial numbers, and attributes measurements when necessary). Seals, surveillance cameras (film and video), and radiation monitors are used to complement item accountability. This approach would have to be carefully examined if considered for classified materials, both in terms of (1) whether it poses problems from the perspective of classification and (2) whether it will satisfy as yet not fully developed nonproliferation or arms control objectives for verification of the classified and sensitive materials.

The first point raises concerns because the anticipated approaches will likely involve some type of radiation measurements, which would reveal classified information if those measurements were done through the traditional application of IAEA NDA measurements. However, it may be possible to consider limited measurements of attribute signatures, as is done in the case of spent fuel, and to use various approaches, including information barriers, to avoid releasing classified information. Such a concept may consist of using "red light/green light" systems that are applied to classified radiation signatures to protect the data (and the analysis algorithms) while allowing determination of whether an item has the declared attributes (green light if it does, or red light if it does not), but such systems have not been fully tested and evaluated. By way of example, and not as a specific proposal, this approach might include specially designed instruments that would verify that a specific item contained at least some agreed minimal quantity of plutonium or some ratios of plutonium isotopes such as $^{239}Pu/^{240}Pu$. In this example, are these attributes appropriate and, if so, can thresholds for quantity and isotopics be defined and be acceptable from both classification and verification perspectives?

The question of whether such an attributes approach could be used to verify excess defense materials requires a clear notion of the objectives in monitoring classified or sensitive items, which are not currently agreed. One way to approach the problem is to compare the materials being subjected to an item accountancy approach (i.e., spent fuel versus classified items such as pits). If the materials are indeed similar, an acceptable approach to one may be seen as potentially acceptable for the other. It is not clear that the reverse applies because the approach may be applicable even if the materials are different.

With these considerations in mind, it is important to revisit the following question: Is an item accounting approach of the kind that was developed to provide verification of spent fuel assemblies applicable to classified or sensitive materials? It may be, but the items are quite different. It will be important to assess the implications of those differences for developing an approach to verifying classified material. In both cases, the items are difficult to measure, but with spent fuel the problems are physical. With classified materials, the problems are driven by national security and classification concerns and involve legal and political limitations. Through the use of attributes, it is possible for the IAEA to verify that spent fuel assemblies are in fact spent fuel, and the objectives of spent fuel verification are well understood within the overall nonproliferation and safeguards context. However, for classified excess materials, the verification objectives are not fully defined, and it has not been shown that it will be possible to use measurements of attributes to verify classified items. Attributes will have to be identified and thoroughly evaluated in the context of objectives and risks. Second, spent fuel does not pose the same issues of ensuring non-diversion to weapons use (often referred to as irreversibility) as does excess weapons materials. Spent fuel is to some extent self-protecting and not directly or readily usable in weapons. Spent fuel contains reactor-grade plutonium, which is weapon-usable, but *is* viewed as not as desirable for weapons and, consequently, not as tempting a material for use by a weapon state. Although the barriers to weapons use or reuse of spent fuel are not insurmountable, especially in a weapon state, the so-called "spent fuel standard" defines, to a large extent, current US thinking about near-term irreversibility. This point is clear, although it should not be overdrawn. Third, and perhaps most importantly, the continuity-of-knowledge gained from following fuel assemblies through their use in reactors to spent fuel storage sites establishes with a high degree of assurance that the stored spent fuel is that which was initially charged to and irradiated in the reactors. This knowledge is essential to verification. Continuity-of-knowledge can in principle be established for excess materials in classified forms, but we probably cannot be certain that the item at the starting point is, for example, a classified weapon component. Is that necessary? Possibly, but the issue remains to be resolved. In this context, it must be noted that the ability to draw independent conclusions of a declared attribute is an essential and important objective provided by the IAEA.

Authentication of measures used to establish independent conclusions is therefore essential to the IAEA; which raises the question of whether adequate attributes (items that would appear in a declaration) can be established, accepted, and confirmed (verified).

The related issue of dealing with anomalies also arises for classified materials. This is important for spent fuel when continuity-of-knowledge is lost and the potential for diversion of full assemblies or of partial assemblies, through pin removal/replacement, may have occurred. In the case of an anomaly involving spent fuel, measures based on radiation or item accounting allow the attributes of spent fuel to be verified in a manner that would re-establish independent confirmation that the safeguarded items are unaltered spent fuel, at least at the gross-defect level. Will it be acceptable or even possible to resolve anomalies of sensitive items at a gross-defect level? Or will a different approach be required? What approach to anomaly resolution will be required for classified items? The inability to resolve anomalies effectively could potentially undermine confidence in the IAEA itself and its ability to provide independent conclusions.

Where are we then? As suggested above, had the two types of materials been similar, it might have been assumed that the approach to one might be applicable to the other. This was not the case. The dissimilarity between spent fuel and classified materials does not demonstrate the inapplicability of item accountancy to pits, but neither does it suggest that it is applicable.

IV. Conclusions

An examination of traditional safeguards on spent fuel reveals that possible "verification" approaches to excess materials in classified form based on item accountancy, "attributes measurements," and C/S are not wholly new; they are well established for unclassified materials. These techniques may be applicable to classified items, but approaches have yet to be identified, fully tested and evaluated for technical and political feasibility and acceptability in inspection regimes that are also not fully developed or agreed. Extensive work is required in these areas. The possibility that the noted techniques may not be appropriate or acceptable has to be considered. Given these considerations, thinking at this time should not be prematurely limited. It may be possible to craft a international (IAEA) monitoring approach for classified materials. However, the prospect of delaying the application of international safeguards until classified materials have been converted to unclassified forms and then placing them under more traditional safeguards must not be excluded. Clearly, some US excess materials have already been converted, and this process can be expected (and is planned) to continue. It is important to point out that the conversion process effectively deals with the handling of classified weapons-grade materials and would remove the difficulty of IAEA verification of classified items. The conversion approach also takes weapon materials one step further away from weapons use. To be realistic, our objectives must value both placing classified or sensitive materials under inspections (if the approaches can be developed and agreed) and converting the material to unclassified forms, which might then be placed under traditional safeguards or other agreed approaches.

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