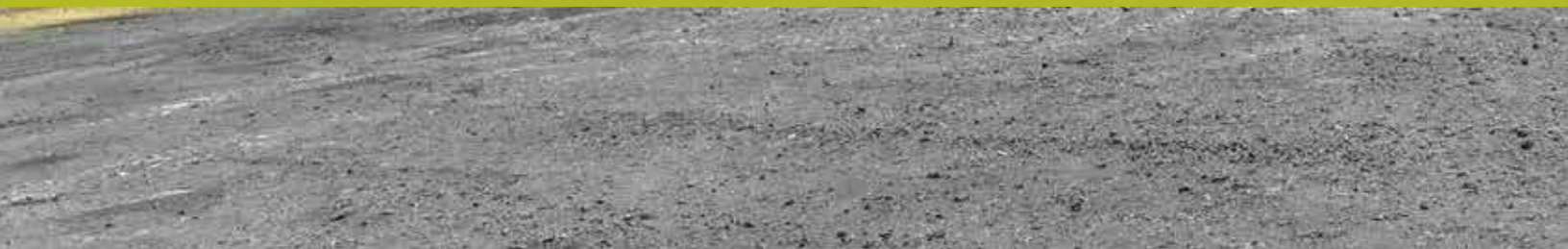




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# CAPTURING THE STARTING POINT

Evolving Nuclear Safeguards  
and the Front End of the  
Nuclear Fuel Cycle | July 2018



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Drums of uranium ore concentrates  
Photo provided by KATCO

# Capturing the Starting Point

The point at which nuclear material becomes subject to comprehensive safeguards agreements with the International Atomic Energy Agency (IAEA) is commonly known as the “starting point of safeguards.” Paragraphs falling under this heading have remained unchanged since the publication of the model Comprehensive Safeguards Agreement (CSA) in 1972, although their interpretation and the measures applied to material both at and before the starting point, have evolved. This has led to the capture by safeguards of more materials upstream in the nuclear fuel cycle that otherwise had fallen outside of international control, creating new obligations for states and industry, particularly for states with conversion facilities and producers of uranium ore concentrates (UOC). It has also led to more verification responsibilities for the IAEA.

This report is the product of two years of research studying the impact of evolving safeguards obligations on states, facility operators, and the IAEA at the front end of the nuclear fuel cycle. It begins by looking at the archives of the IAEA Safeguards Committee (1970–1971) and how the committee determined where safeguards under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) should commence. It then describes how materials at the front end of the nuclear fuel cycle, over time, became subject to strengthened, supplemented, and clarified safeguards; explores the technical and political challenges to the implementation of these measures; and ends with recommendations for effective implementation of these safeguards in today’s circumstances. The report is based on archival research, interviews with current and former IAEA and regional safeguards officials, and representatives of government and industry, as well as site visits to mines, mill, and conversion facilities in Australia, Canada, France, Kazakhstan, and the United States.



## Defining the Starting Point

In April 1970, a month after the NPT entered into force, the IAEA Board of Governors adopted a resolution establishing the Safeguards Committee to consider the content of the safeguards agreements required by the treaty. Composed of representatives from approximately 50 states, the committee held 82 sessions from June 1970 to March 1971. In 1972, the results were published as IAEA document INFCIRC/153 (Corrected), *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*.

Committee members reached consensus early on that mines and ore processing should be excluded from safeguards, but views diverged on whether safeguards should start when source material is processed to special fissionable material or whether safeguards should be put on all source material (including concentrates) containing uranium or thorium. Various concentrations and percentages were proposed, but eventually discarded as inequitable given their effect would be to divide a competitive uranium industry into two groups (one safeguarded and the other unsafeguarded).

They were also considered inadequate in addressing cases when ore processing and concentration processes were combined. With thresholds dropped, a compromise brokered by Finland accepted functional criteria that focused on composition and purity over a quantitative concentration threshold.<sup>1</sup> In the end, paragraphs 33 and 34 of INFCIRC/153 outlined the “Starting Point of Safeguards.” They state:

Paragraph 33.<sup>2</sup> The Agreement should provide that safeguards shall not apply thereunder to material in mining or ore processing activities.

Paragraph 34.<sup>3</sup> The Agreement should provide that:

(a) When any material containing uranium or thorium which has not reached the stage of the nuclear fuel cycle described in sub-paragraph (c) below is directly or indirectly exported to a non-nuclear-weapon State, the State shall inform the Agency of its quantity, composition and destination, unless the material is exported for specifically non-nuclear purposes;

(b) When any material containing uranium or thorium which has not reached the stage of the nuclear fuel cycle described in sub-paragraph (c) below is imported, the State shall inform the Agency of its quantity and composition, unless the material is imported for specifically non-nuclear purposes; and

(c) When any *nuclear material* of a composition and purity suitable for fuel fabrication or for being isotopically enriched leaves the plant or the process stage in which it has been produced, or when such *nuclear material*, or any other *nuclear material* produced at a later stage in the nuclear fuel cycle, is imported into the State, the nuclear material shall become subject to the other safeguards procedures specified in the Agreement. (Italics in original.)

For material that meets the criteria of paragraph 34(c), the “other safeguards procedures” are those set out in Part II of INFCIRC/153. According to the document, all material meeting 34(c) criteria must be included in a State’s initial report to the IAEA (paragraph 62), regardless of use or quantity, with nuclear material accountancy on all physical inventories and inventory changes (paragraphs 63, 64, 65), and access to materials and locations provided to IAEA inspectors (paragraphs 48 and 71). States must notify the IAEA of exports of 34(c) material (paragraph 12), excluding transit States (paragraph 91), but including exports to a State where the material will not be under safeguards (e.g., to a nuclear-weapon State). In the latter case, the exporting State must make arrangements for the receiving State to notify the IAEA of its receipt within three

months (paragraph 94). The importing State is responsible for notifying the IAEA of the anticipated date, location of receipt, and unpacking schedule (paragraph 91).<sup>4</sup>

The reference to “other safeguards procedures” also demonstrates that reporting on exports and imports are considered safeguards, even though the information is not detailed and limited to quantity and composition (and destination, for exports). These paragraphs reflect a compromise accepted by uranium producers (such as Australia, Canada, and South Africa) to report on UOC trade (but not on domestically produced UOC unless it is exported). The same countries also advocated for the words “for nuclear purposes” to ensure that non-nuclear industries such as phosphates and mineral sands are not subject to IAEA reporting (unless their byproducts of uranium and thorium are to be used for nuclear purposes). Others supported the conditioned purpose, arguing that without it, non-notification could become the exception instead of notification becoming the rule.<sup>5</sup>

It should be noted that paragraph 34(a) is specific to exports to non-nuclear-weapon States (NNWS), whereas paragraph 34(b) does not make a distinction on imports. In 1974, the United States, the United Kingdom, and the Union of Soviet Socialist Republics informed the IAEA<sup>6</sup> that they would report on the quantities and composition of imports and exports to and from NNWS for amounts exceeding one “effective kilogram” (i.e., one significant quantity of 10tU).<sup>7</sup> France informed the IAEA that it would apply the same practice in March 1984<sup>8</sup> (INFCIRC/207/Add.1), and China followed in December 1991.<sup>9</sup>

The true “starting point” of safeguards is therefore the limited reporting on exports and imports described in paragraphs 34(a) and 34(b). These paragraphs have not been subject to any subsequent reinterpretation, but have been supplemented by some of the measures in the Additional Protocol as explained below. Paragraph 34(c), however, is the “starting point” of full safeguards procedures, and although its text has not changed, its technical interpretation has evolved.

The language formalized in 34(c) applies to material of the specified purity when it “leaves the plant or process stage,” indicating convergence around the IAEA’s position during committee negotiations that the conversion plant is the first principal nuclear facility in the fuel cycle, and “also the first stage at which the fundamental safeguards concept of material balance accountancy can be effectively applied.”<sup>10</sup> The reference to “process stage” also indicates that safeguards could begin within a plant (not just be applied to its product), addressing cases where fuel fabrication and conversion activities are co-located. The negotiating history does not indicate that committee members considered scenarios in which a uranium processing plant (the stage before conversion) produces UOC that meets the composition and purity outlined in paragraph 34(c).<sup>11</sup> This scenario, however, along with challenges related to the reporting of a conditioned purpose under paragraphs 34(a) and (b), would later prompt reviews of comprehensive safeguards and their starting point.



# Effectiveness and Gaps: Introduction of the Additional Protocol

The first test of the effectiveness of INFCIRC/153 came a decade after negotiations were finished. Two days after Israeli airstrikes destroyed Iraq's Tamuz research reactor, the IAEA's Director General stated that, although inspections of the reactor had not found evidence of noncompliance with the NPT, "a non-NPT country has evidently not felt assured by our findings," and "one can only conclude that it is the Agency's safeguards regime which has been attacked."<sup>12</sup> A month later, in June 1981, the United Nations Security Council issued Resolution 487, which considered the attack a "serious threat to the entire IAEA safeguards regime which is the foundation of the non-proliferation Treaty."<sup>13</sup>

In response, the Director General was tasked at the June 1982 session of the IAEA Board of Governors to prepare a report on safeguards purposes, technical objectives, goals, and approaches. The IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI) was in turn asked to provide recommendations on possible improvements. According to its report on safeguards-related questions, SAGSI advised that it would be inappropriate to change the provisions of paragraph 34 of INFCIRC/153, either by amendment or by reinterpretation, in order to apply the "other safeguards procedures" referred to in paragraph 34(c) to uranium concentrate.<sup>14</sup> It did offer that countries with INFCIRC/153-type agreements could, if desired, conclude an INFCIRC/66/Rev.2-type agreement with the IAEA to provide for the safeguarding of uranium concentrate.<sup>15</sup> It does not seem that the IAEA or any countries followed up on the SAGSI suggestion.

Ten years later, activities in Iraq again tested the effectiveness of INFCIRC/153, this time with revelations that Baghdad had been developing a clandestine nuclear weapons program and was closer to building a bomb than initially suspected. Coupled with the discovery of undeclared plutonium in North Korea, the IAEA embarked on a process to strengthen its ability to detect diversion, whether involving declared or undeclared activities, by including information within the state as a whole under CSAs and introducing the Additional Protocol (AP) in 1997, which expands the information provided to the IAEA as well as the IAEA's access across the nuclear fuel cycle. With the introduction of the AP, the IAEA shifted from a reliance on verifying declared material under INFCIRC/153 to actively looking for indicators of undeclared activities and materials, which some have described as transforming inspectors from "accountants to detectives."<sup>16</sup>

The AP authorizes the IAEA to access more information related to “pre-34(c)” material, including material intended for non-nuclear purposes. For States with a CSA only, reporting to the IAEA begins with material that meets the criteria in paragraphs 34(a) and (b). If such material is not destined for nuclear purposes (such as for use in ceramics), then it is not reported under INFCIRC/153. For NNWS that have both CSAs and additional protocols in force, reporting to the IAEA begins with uranium and thorium holdings, including their location, operational status, estimated capacity, and annual production from mines and concentration plants and their internationally traded products such as UOC,<sup>17</sup> whether intended for nuclear<sup>18</sup> or non-nuclear purposes.<sup>19</sup> Locations are also declared under AP Article 2.a (vi)(a) if they hold more than 10 metric tons (MT) of uranium or 20 MT of thorium as source material not suitable for fuel fabrication or enrichment. These amounts are equivalent to one “significant quantity,” a basic parameter used in IAEA safeguards to describe the quantity of material for which the possibility of manufacturing a nuclear explosive device cannot be excluded.<sup>20</sup>

Notably, one NNWS safeguards arrangement that is currently in force goes beyond the CSA and the AP, marking the first time the IAEA is monitoring a state’s UOC production and inventory in detail. Under the Joint Comprehensive Plan of Action (JCPOA) reached on July 14, 2015, between China, the European Union, France, Germany, Iran, Russia, the United Kingdom, and the United States, the IAEA monitors the production of UOC produced by Iran from all concentration plants for 25 years.<sup>21</sup> Paragraphs 68 and 69 of Annex 1 of the JCPOA further provide that all UOC produced in Iran or obtained from other sources and transferred to the conversion plant in Esfahan (or any future conversion facility) will be monitored.<sup>22</sup>

For countries that have minimal or no nuclear activities, Small Quantity Protocols (SQPs) are attached to their CSAs. The original 1974 text of SQPs<sup>23</sup> allows most of the procedures in Part II of CSAs to be held in abeyance while the State continues to qualify for an SQP. In 2005, the IAEA modified the eligibility criteria, making the SQP unavailable to States with an existing or planned facility and reducing the number of measures held in abeyance.<sup>24</sup> The texts of both the original and modified SQPs require reporting on imports and exports of pre-34(c) material as well as 34(c) material. The information reported on trade of pre-34(c) material may be consolidated and submitted annually, although the IAEA prefers to receive such information within 30 days after import/export.<sup>25</sup>

Table 1 outlines the various safeguards agreements and their relevant provisions related to pre-34(c) and 34(c) material for NNWS subject to CSAs, the AP, SQPs, and the JCPOA.

**TABLE 1. REPORTING REQUIREMENTS OF CSAs, AP, JCPOA AND SQP**

Material	Reporting	INFCIRC/ 153 (CSAs)	INFCIRC/ 540 (AP)	JCPOA	SQP (and modified SQP)	
Pre-34(c) material	Safeguards do not apply to material in mining or ore processing activities	Paragraph 33				
	Plans for nuclear development		2.a(x), 3			
	U mining, U and Th concentration plants		2.a(iii) 2.a(v) 3	Paragraph 15, & paragraphs 68, 69 of Annex I		
	Locations holding >10 tU and aggregate in State if >10 tU (whether intended for nuclear or non-nuclear use)		2.a(vi)(a)			
	Quantity and composition of exports directly or indirectly to NNWS for nuclear purposes  Imports unless imported for non-nuclear purposes	34(a)  34 (b)				In both – reported annually (more frequently preferred)
	Imports and exports for non-nuclear purposes			2.a(vi)(b) 2.a(vi)(c)		

Material	Reporting	INFCIRC/ 153 (CSAs)	INFCIRC/ 540 (AP)	JCPOA	SQP (and modified SQP)
34(c) material	Initial report on all nuclear material	62			Mod SQP
	All exports and imports, known as "international transfers" (whether for nuclear or non-nuclear purposes)	91, 92, 93			Paragraphs 91, 95-96

For those with CSAs but no AP, the IAEA concludes whether declared nuclear material remains in peaceful activities. For countries with both a CSA and an AP, the IAEA can conclude on the non-diversion of declared nuclear material and the absence of undeclared nuclear material and activities, eventually leading to a broader conclusion that all nuclear material remains in peaceful activities.

## Clarifying Paragraph 34(c)

For 30 years (1972–2002), the practice was to apply paragraph 34(c) to the product of conversion plants, namely uranium dioxide (UO<sub>2</sub>) for fabrication into fuel and uranium hexafluoride (UF<sub>6</sub>) and uranium tetrachloride (UCl<sub>4</sub>) for subsequent enriching. In 2003, verification activities in Iran revealed undeclared activities related to the importing, storage, and processing of nuclear material, including the production of uranyl nitrate (along with the production of uranium metal, ammonium uranyl carbonate, UO<sub>2</sub> pellets, and uranium wastes from imported material).<sup>26</sup> This led to the IAEA reviewing paragraph 34(c) and issuing a series of clarifications. These clarifications captured more materials upstream in the nuclear fuel cycle, applying nuclear material accountancy to material in conversion plants that previously had not been fully safeguarded.

The first clarification was introduced in October 2003 with Policy Paper 18 (PP18).<sup>27</sup> It stated that uranyl nitrate (or the first practical point earlier) that met, or was close to meeting, the impurity levels specified for nuclear-grade uranyl nitrate solution of

a commercial standard (ASTM C788-98<sup>28</sup>) was subject to paragraph 34(c).<sup>29</sup> PP18 also captured oxides such as purified uranium trioxide (UO<sub>3</sub>) with impurity levels that met, or were close to meeting, the commercial standard for nuclear-grade, sinterable UO<sub>2</sub> (ASTM C753-99). The clarification was specific to material in conversion facilities and affected a handful of non-nuclear-weapon states with a CSA and refining or conversion facilities, specifically Argentina, Canada, Iran, Romania, and eventually Brazil.<sup>30</sup>

After PP18 was issued, more cases related to undeclared uranium processing and conversion would follow, namely in Libya in 2003,<sup>31</sup> in Egypt<sup>32</sup> and South Korea<sup>33</sup> in 2004, and Syria in 2007.<sup>34</sup> In all cases, the conversion activities were small-scale. The activities in Egypt and South Korea were discovered as a result of the implementation of strengthened measures that successfully identified previously undeclared activities under, respectively, the CSA and the AP. The two governments were open and cooperative, as was Libya, which had announced in December 2003 its intention to eliminate its clandestine conversion and enrichment program. After further investigation, the IAEA concluded that the activities in Libya, Egypt, and South Korea had been explained and verified. For Syria, the Agency conducted inspections in 2008 after receiving information alleging that a site at Dair Alzour, destroyed by Israel in September 2007, had been a nuclear reactor under construction. The IAEA found previously unreported activities and materials, such as the preparation of tens of grams of uranyl nitrate at Syria's Miniature Neutron Source Reactor (MNSR) using UOC produced at Homs, as well as a small quantity of undeclared uranyl nitrate at the MNSR.<sup>35</sup> According to the IAEA report on Syria in 2014, Damascus had "not engaged substantively with the Agency," and maintains that the building at Dair Alzour was a non-nuclear military installation.<sup>36</sup>

With these cases in mind, the IAEA updated PP18 in 2009 to include research and development facilities. The 2009 version dropped the earlier reference to the ASTM standards for "high purity" uranyl nitrate and UOC without clarifying what was to be considered "pure."<sup>37</sup> The ASTM standards were removed in response to questions regarding the IAEA's legal remit to reference commercial standards given that INFCIRC/153 and INFCIRC/540 refer to "purity" and "composition" of materials, not thresholds or standards.<sup>38</sup>

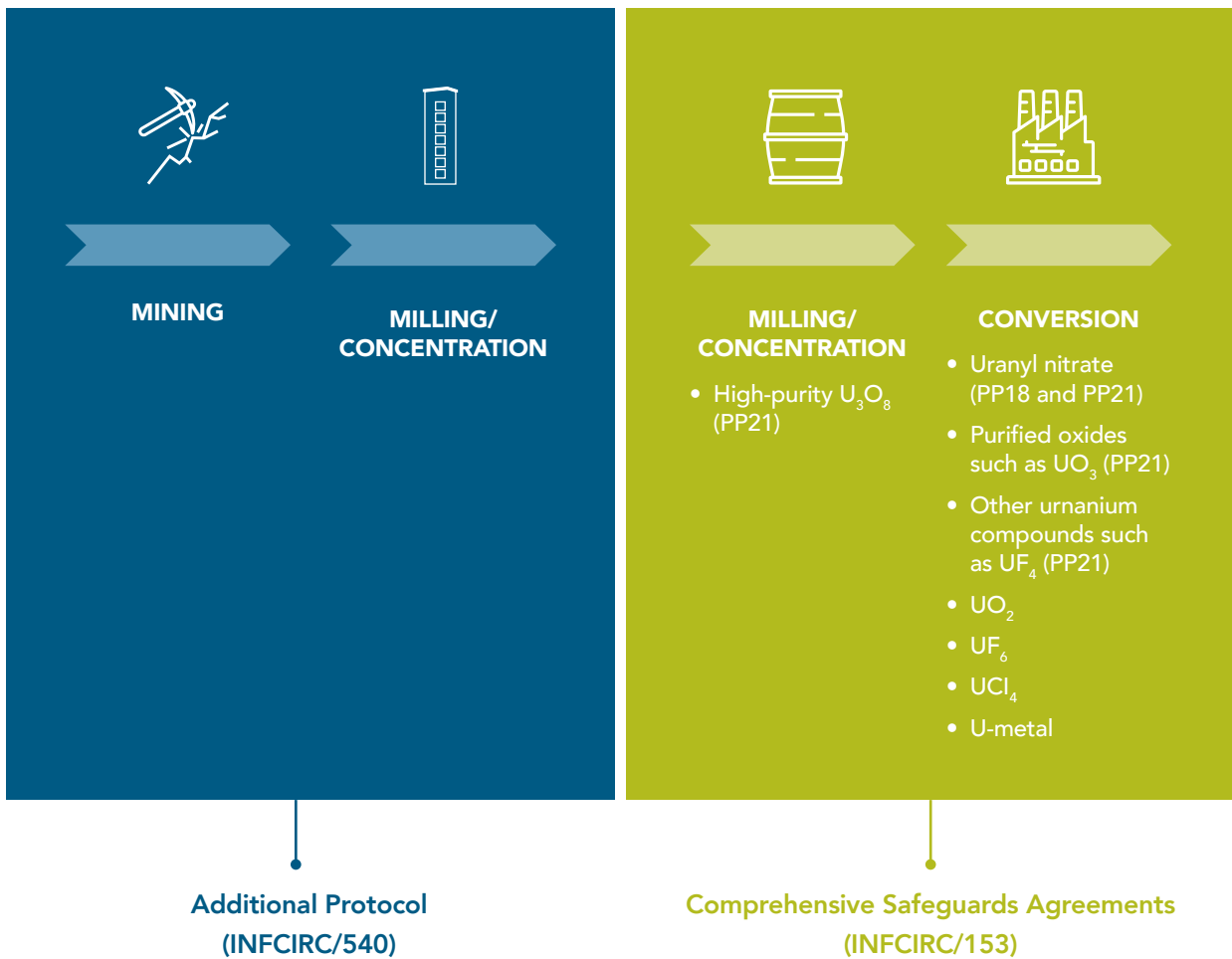
The removal of the ASTM standards, however, led to complaints from within the IAEA, particularly from the inspection divisions of the Department of Safeguards, which requested more detailed instructions for implementation. At the same time, some uranium producers began advertising their UOC as directly suitable for fuel fabrication.<sup>39</sup> This led to the development of a new policy paper to replace the earlier versions. In 2013, the IAEA introduced Policy Paper 21 (PP21).

Most of the language of the 2009 version was retained in PP21,<sup>40</sup> except that it added reference to ASTM-C753-04<sup>41</sup> (which superseded ASTM C753-99<sup>42</sup>), clarifying that any UOC that meets the commercial standard specification for sinterable UO<sub>2</sub> (product

of milling/concentration)<sup>43</sup> would be captured under paragraph 34(c). PP21 included purified uranyl nitrate solution (produced during conversion)<sup>44</sup> as suitable for fuel fabrication or isotopic enrichment;<sup>45</sup> but it was not limited to conversion facilities, as was the case with PP18. Instead, PP21 focuses on materials wherever they are located, addressing not only pathways for enrichment but also for fuel fabrication.

Table 2 outlines the very front end of the nuclear fuel cycle and materials captured under the AP and INFCIRC/153.

**TABLE 2. FRONT END MATERIALS CAPTURED BY SAFEGUARDS**



# Implementation Challenges

The nature of source material is one of the biggest challenges in applying safeguards and capturing the specific point from which PP18 and PP21 should be applied. Both conversion facilities and mills process high volumes of material in loose, bulk form. Conversion plants, for example, are essentially large chemistry sets with complex piping that carry uranium along with water and gases, with the flow rates, volumes, and composition of nuclear material fluctuating throughout the process. With such large volumes, the weight difference between material registered in a book inventory and the actual weight physically inventoried can vary widely at bulk facilities.<sup>46</sup> These variances, or “materials unaccounted for” (MUF), are based on weight and volume measurements to estimate the amount of material subject to safeguards at different stages of the process. Nuclear material also accumulates in piping and equipment, further affecting measurement uncertainties and complicating accounting. Known as “nuclear material hold-up,” this material is underscored by the IAEA as “notoriously difficult to quantify and control.”<sup>47</sup>

To this end, applying PP18 and nuclear material accountancy to uranyl nitrate is technically challenging. In Canada, Cameco’s Blind River Refinery has an annual throughput of 18,000 MT of  $UO_3$ , making it the world’s largest refinery, producing  $UO_3$  to feed the Port Hope facility for conversion into  $UF_6$  or  $UO_2$ .<sup>48</sup> The level of MUF is therefore high at Blind River, with measurement systems having a variance upwards of 2-3 percent, or 20,000–30,000 kg per year.<sup>49</sup> Accordingly, some level of MUF is expected at bulk handling facilities because of measurement uncertainties and the nature of the process. MUF is not in itself an indication that diversion has occurred, but the significance of MUF does need to be evaluated by the IAEA.<sup>50</sup>

The “starting point” at Blind River was agreed, after two years of talks by the IAEA, Cameco, and the Canadian Nuclear Safety Commission (CNSC), to begin where drums of UOC from Canada and abroad are fed into the process (at the drum dumper). Cameco preferred a point later within the process when uranyl nitrate is fed into the denitration furnace, but in the end full safeguards were determined to apply at the “first practicable point earlier” (i.e., “upstream”) in the plant, as suggested by PP18. With Blind River’s experience limited to the occasional Complementary Access requested under the AP, PP18 marked the first time the facility was captured by full safeguards.<sup>51</sup> Therefore, for Canada, although the definition remained the same, PP18 “moved” the starting point of full safeguards 630 kilometers from where it had been historically applied at the Port Hope conversion facility. The new starting point did not require accountancy on the thousands of drums stored at the site, as UOC remained a “pre-34(c)” material. PP18 also fully captured the Port Hope facility.



UOC Drum Packing  
Source: Energy Resources Australia

Negotiations in Argentina ended with a different starting point for the conversion facility at Cordoba. Although uranyl nitrate is technically difficult to measure in liquid form, Argentina's position was to apply PP18 exactly at the point of uranyl nitrate in process (not before, as in Canada). After five years of negotiations, it was agreed that the starting point would begin with measuring the liquid store in a retention tank. The first IAEA inspection covered by PP18 took place at Cordoba in January 2013.<sup>52</sup> Argentina is currently constructing another  $\text{UO}_2$  conversion plant in Formosa with a design capacity of 230 MTU/yr. It uses the same process as the Cordoba plant, and a similar starting point is anticipated. Operations at Formosa are planned to begin in 2020.



Implementation at Cordoba is thus challenged by measurement inaccuracies associated with the liquid retention store, but with an annual capacity of just 200 MTU/yr,<sup>53</sup> Cordoba is exponentially smaller than Blind River and runs batches (versus continuous flow) that are simpler to safeguard by measuring the tank before and after each batch. Argentina also differs from Canada in its safeguards agreements with the IAEA. It does have a CSA with the IAEA based on INFCIRC/153, but it is quadripartite (INFCIRC/435), concluded with Brazil, the IAEA, and the Brazilian-Argentine Agency for the Accounting and Control of Nuclear Materials (ABACC). Unlike Canada, neither Argentina nor Brazil has an additional protocol to its CSA, and the IAEA does not have expanded access across their fuel cycles. Accordingly, the politics of safeguards are different than in Canada, where implementation of PP18 was viewed as a prerequisite to attaining the broader conclusion that Canada had been aiming for since signing the AP in 2000.<sup>54</sup> Conversely, Brazil has stated that it has no intention of implementing the additional protocol without significant steps in global nuclear disarmament, and although Argentina has said little on its non-signature, it might not wish to move without Brazil.

In Brazil, PP18 applies to the navy's pilot and testing facilities for its naval propulsion program at the Aramar Experimental Center, located in Iperó in the state of São Paulo. The infrastructure includes a partially constructed uranium conversion plant, which will produce  $UF_6$  (via nitrate). According to ABACC, the conversion plant at Aramar has been redesigned to allow for the verification of material. It has a design capacity of 40 MT/yr.

The measurement challenges are similar for the implementation of PP21 at mills and concentration plants where truckloads of ore are fed into crushers and then mixed with alkali solutions or sulphuric acid to leach uranium from the ore to produce triuranium octoxide ( $U_3O_8$ ). The McClean Mill in Canada, one of the top producing mills in the world, produced 17.3 million pounds of  $U_3O_8$  (7,700 MT) from Cigar Lake ore in 2016.<sup>55</sup> The implementation of PP21 is further challenged by the relatively high purity of the commercial standard, because potential proliferators could produce a lower purity or spike UOC with impurities (such as manganese) that can be easily removed by an importer, to avoid safeguards. For committed diverters, the threshold only needs to be good enough for diversion, not for commercial purposes.

At the same time, the purity of materials produced at uranium mines and concentration plants may vary by time and batch, meaning that a facility that does not meet ASTM standards today could potentially produce material that does meet standards in the future. The nature of UOC also means that purity in a batch that meets the ASTM standard may alter over time and not meet the standard after a few months (but still be pure enough to feed). Consequently, the challenge for implementing PP21 is the uncertainty of facilities' ability to consistently produce

material of ASTM-level purity. As a result, the level of IAEA resources devoted to different uranium producers could vary widely.

Although PP21 was in part prompted by some UOC producers advertising their product as pure enough for fuel fabrication, the true scale of the amount of UOC produced globally that meets the criteria of PP21 is unknown. The IAEA did not conduct a study before PP21 (nor has it since) of whether pure UOC production is more widespread than that of the original advertisers, and attempts by outsiders (such as the Stimson Center) to study this are challenged by relying on information from industry, government, and IAEA sources that can be contradictory or incomplete. One industry representative, for example, mentioned that its UOC met the ASTM standard, while a converter receiving that company's product said it did not.<sup>56</sup> Some countries or industry producers also consider the topic sensitive and do not respond to questions on their material unless asked by a regulator. Without access to all conversion, fuel fabrication, and research and development facilities, it is nearly impossible for researchers outside of the IAEA (including governments and industry) to specify the percentages or volumes of UOC that are suitable globally for fuel fabrication.

Moreover, there are no examples to date of a specific "starting point" associated with PP21. According to interviews conducted with former and current IAEA officials, state regulators, and industry officials, many uranium producers have received little or no communication from the IAEA or their own State Regulatory Authorities (SRAs) on PP21, while others have received only partial information in a formal letter from the IAEA in 2014, including a one-page overview with excerpts from PP21 and a request for a formal response on whether any material in-country might be affected. States then can declare whether any UOC meets the ASTM standard in PP21. The IAEA has not produced any guidance on implementing PP21 or stated that a guidance document will be produced outside of the *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols*, published in 2016. In relation to paragraph 34(c), it states "the IAEA should be consulted in cases where it is unclear whether or not source material meets the conditions of paragraph 34(c)."<sup>57</sup> This suggests that the IAEA does not anticipate that significant additional verification activities will result from PP21.<sup>58</sup>

The issue is, in part, due to IAEA policies in which the Agency maintains that policy papers are internal guidance documents for inspectors. The decision to share even excerpts of PP21 with some SRAs was contentious within the Department of Safeguards, as its application was (and still is) viewed as being country-specific based on acquisition path analysis in devising verification activities in states with integrated safeguards. In the end, the three operating divisions of the Department of Safeguards were tasked with informing the countries in their portfolios of PP21's requirements. The Division of Safeguards Concepts and Planning is responsible for ensuring that

verification approaches are consistent across all three operations divisions while also analyzing all information received from States. Of the major uranium producers among the NNWS, Kazakhstan, Namibia, and Niger are not under integrated safeguards.

Conversely, for PP18, the IAEA published guidance on *International Safeguards in the Design of Uranium Conversion Plants* in 2017. It states that UOC feed material may “not be subject to full safeguards procedures” and that, in general “purified oxides of uranium and purified solution of uranium are subject to full safeguards” in conversion plants, “while yellowcake and UOC often are not.”<sup>59</sup> It notes that paragraph 34(c) often begins at the uranyl nitrate (UNO<sub>3</sub>) stage following solvent extraction purification, and that in cases where applying accounting procedures at that point are not practical or economical, “safeguards measures begin at some point earlier (upstream) in the plant, e.g. at the input of UOC.” It further highlights that the point at which materials reach the criteria of 34(c) “will be determined by the IAEA and discussed with the [State Regulatory Authority] SRA.”<sup>60</sup> This publication is the fourth in the IAEA Nuclear Energy Series to provide guidance on the inclusion of safeguards in nuclear facility design and construction, but the first to focus specifically on conversion plants.

## Conclusion and Recommendations

Clarifications to the “starting point” offer a case study in the evolution of the IAEA’s safeguards system and its progress toward an integrated and state-level approach. Varied volumes of the input and output of bulk material, coupled with measurement inaccuracies, further complicate implementation, requiring more effort and communication between the IAEA and States in both defining and implementing the starting point. The cases of PP18 and PP21 demonstrate that a more streamlined, transparent process is necessary within the Agency. For SRAs, the same applies in their outreach to domestic industry as well as to their discussions with the IAEA on understanding safeguards obligations, and how they are evolving – whether for integrated safeguards or for those with only CSAs or a SQP. The following recommendations address two levels of the process: the IAEA and national regulators.

## **RECOMMENDATION 1:**

### **MAKE THE STARTING POINT PUBLIC**

Policy papers that are considered internal guidance for IAEA inspectors do not need to be made public in their entirety, but any clarifications to INFCIRC/153, particularly to its starting point for full safeguards procedures, should be communicated in some form publicly, and followed up with all producers or consumers of uranium, no matter how small. Without this, the process becomes unduly bureaucratic and mysterious, leaving members of industry and other stakeholders to seek secondhand information or continue to believe that the historical interpretation of full safeguards starts at the output, rather than within conversion facilities.

## **RECOMMENDATION 2:**

### **STATE REGULATORY AUTHORITIES PROVIDE GUIDANCE TO DOMESTIC STAKEHOLDERS**

It is incumbent upon States and their regulatory authorities to ensure that safeguards obligations are implemented. In the absence (and even in the presence) of IAEA guidance, national authorities are responsible for communicating and discussing any changes to interpretations of safeguards and their implications for implementation. This outreach should include research and development facilities as well as operators of mills and concentration, conversion and fuel fabrication plants.

# Endnotes

- 1 Cindy Vestergaard, "The History of the Starting Point: A Study of the Archives" (paper, 57th Annual Institute for Nuclear Material Management (INMM) Meeting, Atlanta, GA, July 24-28, 2016).
- 2 IAEA, *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, INFCIRC/153 (Corrected), 1972, para. 33.
- 3 Ibid, para 34.
- 4 IAEA, *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols*. (Vienna: IAEA, 2016), 40, [https://www-pub.iaea.org/MTCD/Publications/PDF/SVS-21\\_web.pdf](https://www-pub.iaea.org/MTCD/Publications/PDF/SVS-21_web.pdf).
- 5 Cindy Vestergaard, "The History of the Starting Point," 8.
- 6 IAEA, *Notification to the Agency of Exports and Imports of Nuclear Material*, INFCIRC/207, July 26, 1974.
- 7 Sharon Squassoni, Stephanie Cooke, Robert Kim, and Jacob Greenberg, *Governing Uranium in the United States*, (Washington, DC: CSIS, March 2014), 4, [https://csis-prod.s3.amazonaws.com/s3fs-public/legacy\\_files/files/publication/140228\\_Squassoni\\_GoverningUranium\\_WEB.pdf](https://csis-prod.s3.amazonaws.com/s3fs-public/legacy_files/files/publication/140228_Squassoni_GoverningUranium_WEB.pdf).
- 8 IAEA, *Notification to the Agency of Exports and Imports of Nuclear Material*, INFCIRC/207/Add.1, March 1, 1984.
- 9 IAEA, *Notification to the Agency of Exports and Imports of Nuclear Material*, INFCIRC/207/Add.2, December 1, 1991.
- 10 This was articulated in the first report circulated by the Director General to the committee. See IAEA, "Safeguards Agreements in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons: Note by Director General," GOV/COM.22/3, May 29, 1970.
- 11 Craig Everton, Stephan Bayer, and Michael East, "Safeguarding Uranium Production and Export Conventional and Non-Conventional Resources" (paper, ESARDA workshop, Aix-en-Provence, France, October 2011).
- 12 H. Greumm, "Safeguards and Tamuz: Setting the Record Straight," *IAEA Bulletin* 23, no. 4 (1981).
- 13 United Nations Security Council, *Resolution 487*, June 19, 1981, <https://www.securitycouncilreport.org/atf/cf/%7b65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7d/Disarm%20SRES487.pdf>.
- 14 IAEA, *Report on Safeguards-Related Questions*, GOV/2107, January 19, 1983.
- 15 Ibid.
- 16 Theodore Hirsch, "The Additional Protocol: What It Is and Why It Matters," *The Nonproliferation Review* (Fall–Winter 2004): 143.
- 17 IAEA, *Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540 (Corrected), article 2.a(v). September 1997.
- 18 Paragraphs 34(a) and (b) of INFCIRC/153 (Corrected) provide that a State shall inform the IAEA of the quantity and composition of material containing uranium or thorium when exported or imported by the State.
- 19 IAEA, AP, articles 2.a(v) and (vi).
- 20 CSIS, "Pit to Port," *Governing Uranium*, [http://uranium.csis.org/pit\\_to\\_port/](http://uranium.csis.org/pit_to_port/).
- 21 On May 8, 2018, the United States withdrew from the JCPOA, terminating U.S. participation in the arrangement. At the time of this writing, other parties remain involved: China, the European Union, France, Germany, Iran, Russia, and the United Kingdom. See "Joint Comprehensive Plan of Action, Vienna, July 14, 2015: <https://www.state.gov/documents/organization/245317.pdf>. See also Donald J. Trump, "President Donald J. Trump is Ending United States Participation in an Unacceptable Iran Deal," [www.whitehouse.gov/briefings-statements/president-donald-j-trump-ending-united-states-participation-unacceptable-iran-deal/](https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-ending-united-states-participation-unacceptable-iran-deal/).
- 22 Cindy Vestergaard, "Safeguarding the Front-end of the Nuclear Fuel Cycle," *Trust & Verify*, no. 150 (July–September 2015): 4, <http://www.vertic.org/media/assets/TV/TV150.Final.pdf>.
- 23 IAEA, *The Standard Text of Safeguards Agreements in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons: Note by the Director General*, GOV/INF/276/Annex B, August 22, 1974.
- 24 IAEA, *The Standard Text of Safeguards Agreements in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons: Revision of the Standardized Text of the 'Small Quantities Protocol'*, GOV/INF/276/Mod.1 and Corr.1, February 21, 2006.
- 25 IAEA, *Safeguards Implementation Guide for States with Small Quantities Protocol*, Services Series 22 (Vienna: IAEA, 2013), 20.
- 26 IAEA Board of Governors, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, GOV/2003/40, June 6, 2003.
- 27 IAEA Department of Safeguards, *Policy Paper 18: Safeguards Measures Applicable in Conversion Plants Processing Natural Uranium*, SMR 2.18, October 1, 2003.
- 28 ASTM International, *Standard Specification for Nuclear-Grade Uranyl Nitrate Solution*, Designation C-788-98. (Reapproved as C-788-03 in 2003.)
- 29 Cindy Vestergaard, "Safeguarding the Front-end of the Nuclear Fuel Cycle."

- 30 In Brazil, the navy runs pilot and testing facilities for its nuclear propulsion program at the Aramar Experimental Center, located in Iperó in the region of Sorocaba, in the state of São Paulo. Aramar's infrastructure includes a partially constructed uranium conversion plant, which will produce UF<sub>6</sub> (via nitrate) for use in the Brazilian enrichment program. According to the Agency for the Accounting and Control of Nuclear Materials, the conversion plant at Aramar has been redesigned to allow for verification of material covered by PP18. See Cindy Vestergaard, *Governing Uranium Globally*, *DIIS Report 9* (2015): 56.
- 31 IAEA Board of Governors, *Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya*, GOV/2004/12, February 20, 2004.
- 32 IAEA Board of Governors, *Implementation of the NPT Safeguards Agreement in the Arab Republic of Egypt*, GOV/2005/9, February 14, 2005.
- 33 IAEA Board of Governors, *Implementation of the NPT Safeguards Agreement in the Republic of Korea*, GOV/2004/84, November 11, 2004, para. 38.
- 34 IAEA Board of Governors, *Implementation of NPT Safeguards Agreement in the Syrian Arab Republic*, GOV/2010/63, November 23, 2010, para. 8.
- 35 Ibid.
- 36 IAEA Board of Governors, *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic*, GOV/2014/44, September 3, 2014, paras. 2 and 3.
- 37 Cindy Vestergaard, "Safeguarding the Front-end of the Nuclear Fuel Cycle."
- 38 As noted in discussion with former and current officials from the IAEA in May 2016, March 2018, and April 2018.
- 39 IAEA, *Determination of Uranium Bearing Materials Meeting the Conditions of Paragraph 34(c) of INFCIRC/153 (Corrected) (Policy Paper 21)*, SG-PL-12684 (Policy Paper 21), para. 6.
- 40 Ibid.
- 41 ASTM International, *Standard Specification for Nuclear-Grade, Sinterable Uranium Dioxide Powder*, Designation C753-04 (Reapproved 2009).
- 42 Which in turn has been superseded by ASTM C753-16a.
- 43 That is, meeting the standard in ASTM C753-99, *Standard Specification for Nuclear Grade, Sinterable Uranium-Dioxide Powder*, which has since been replaced by ASTM C753-16.
- 44 That is, purified uranyl nitrate meeting the standard in ASTM C788-98, *Standard Specification for Nuclear-Grade Uranyl Nitrate Solution*, which has since been superseded by ASTM 788-03, *Standard Specification for Nuclear Grade Uranyl Nitrate Solution or Crystals*.
- 45 IAEA, Policy Paper 21, para. 18.
- 46 IAEA, *Nuclear Material Accounting Handbook*, IAEA Services Series No. 15 (Vienna: IAEA, 2008), 9.
- 47 IAEA, *International Safeguards in the Design of Uranium Conversion Plants*, IAEA Nuclear Energy Series, no. NF-T-4.8, 2017, 12.
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- 49 As noted in discussion during site visit to Blind River Refinery, May 5, 2017.
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- 51 K. E. Owen, "Implementation of IAEA Policy Paper 18 in Canada," IAEA-CN-148/39, 157.
- 52 Cindy Vestergaard, "Governing Uranium Globally," 55.
- 53 CSIS, "Conversion by Country."
- 54 K.E. Owen, "Implementation of IAEA Policy Paper 18 in Canada," 157.
- 55 Cameco, "Cameco Update: Cigar Lake Operation," May 2017, [https://www.cameconorth.com/uploads/downloads/factsheets/Cigar\\_Lake\\_2017.pdf](https://www.cameconorth.com/uploads/downloads/factsheets/Cigar_Lake_2017.pdf).
- 56 Which does not mean that a batch of material did not meet the specification at another conversion plant or even that a batch matching the criteria before shipment no longer was suitable when it reached the converter. See Stephen LaMontagne, Maia Gemmill, and Cindy Vestergaard, "Impact of IAEA Policy Paper 21 on Uranium Producers and IAEA Verification Activities," BNL-112262-2016-IR (Brookhaven National Laboratory, May 2016).
- 57 IAEA, *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols*, 20.
- 58 Stephen LaMontagne, Maia Gemmill, and Cindy Vestergaard, "Impact of IAEA Policy Paper 21 on Uranium Producers and IAEA Verification Activities."
- 59 IAEA, *International Safeguards in the Design of Uranium Conversion Plants*, 12.
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