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SESSION 36: TYPICAL IAEA INSPECTION PROCEDURES FOR MODEL PLANT

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I. INTRODUCTION

During this session we are going to consider Agency inspection procedures at a bulk facilty, or to be more specific, at a Low Enriched Uranium (LEU) fuel fabrication plant. After this session, I expect you not only to know the basic objectives of Agency operations at a LEU fabrication plant but also to understand the features of Agency inspection activities. You should be able to make your own critical judgement on the scope and adequacy of these inspection activities, which in turn will help you to understand the problems related to inspections and problems inspectors are confronted with.

Please note the following: this presentation makes reference to a model LEU plant, however, since the Agency is not in a position to reveal information on inspections, any data quoted here may or may not reflect actual plant data. The inspection procedures described later may or may not be identical to actual practices; it is obvious that there may be many variations in safeguards approaches at different facilities.

I take the risk of repeating certain facts and issues which were discussed during the many preceding sessions, but I believe that the following introductory remarks will put the operational part of Agency activities into the right perspective, i.e. what is done and why it is done.

International safeguards is committed to produce something, the product being a statement sent formally to the government of the country. There are 2 types of such statements: one simply summarises the activities carried out and the other presents the conclusions drawn as a result of these activities. There is a sequence of actions and interactions to achieve this product:

- The State provides Design Information on a given facility, (DIQ = Design Information Questionnaire).
- Examination by the Agency of design information and conclusion of a facility attachment.
- Provision of accounting reports by the State.
- IAEA inspections to verify information provided in reports.
- Evaluation of inspection data, preparation of inspection reports and production of statements.

In other words, there are two groups of actions, the providing of information and the verification of this information through inspections. These inspections, i.e. the operational aspect of Agency safeguards, will be described in more detail later on.

From the data provided by the State in the DIQ the Agency has information on the location of the facility, its use or purpose, its throughput, its material accountancy procedures, its storage locations and its nuclear materials management system. This information and information collected during so-called "ad hoc inspections" enables the Agency to negotiate a facility attachment and thereby provide the necessary "infrastructure" for safeguards implementation, namely MBAs, KMPs, procedures for PITs and PIVs, provisions for records and reports, and most important, inspection effort and scope of inspections.

Once more, let me emphasize that international safeguards is not a police kind of operation. It will never search for undeclared material, but rather verify the correctness of an operator's statement regarding the possession of nuclear material. In other words, the object of Agency safeguards is to verify the compliance with the provisions of a voluntary safeguards agreement(e.g., INFCIRC/153 or 66) as specified in a facility attachment.

II. SAFEGUARDS OBJECTIVES OF AGENCY SAFEGUARDS

Our model plant is a bulk facility covered by an NPT-type of safeguards agreement. What is the task of this technical instrument called safeguards? According to paragraph 28 of INFCIRC/153,\ the safeguards objectives are described as "timely detection of diversion of signficant quantities and deterrence by the risk of early detection". It is necessary to translate such terms as "timely", "significant" or "risk" into technical detection goals (quantities). These goals serve as guidelines for developing plant specific safeguards approaches which then contain concrete instructions for inspection activities (inspection goals). The connection between safeguards objectives, detection goals, safeguards approach, and inspection goals is illustrated in Annex A.

Briefly, for a LEU fuel fabrication plant, the safeguards objective is the detection of the diversion of 75kg (= 1 SQ) or more of contained U235 within a time not exceeding one year. Do not confuse this detection goal quantity, which we may call a basic safeguards target value, with the inspection goal which I will explain in a moment.

III. PLANT DESCRIPTION AND SELECTION OF SAFEGUARDS APPROACHES

The plant under consideration is a typical medium size capacity plant with the following characteristics:

- It produces assemblies for LWRs containing uranium of low enrichment, normally within the range of 2 to 4%, maximum 5%.
- The annual throughput is about 400t of uranium, nominal enrichment of 3%.

- The feed material is low enriched UF_6, conversion to UO_2 is made at this plant.
- The main process steps are: coversion of UF_6 to UO_2 powder, preparation of sintered pellets, canning of pellets in rods or packing of pellets into boxes for shipment, assembling of rods in fuel assemblies; scrap recovery is possible.
- Products leaving the plant are fuel assemblies and sintered pellets.
- Physical Inventory Taking by plant operator = twice a year.
- Based on past experience, an operator had closed his material balance with an accuracy that met international standards.

When designing a safeguards approach, one would first analyse diversion possibilities and associated concealment methods; a few typical examples are listed in Annex B. The selected safeguards approach must incorporate measures to counter these concealment methods. Generally, these safeguards measures fall into two categories; careful audit procedures to detect falsifications and physical inspection of the material to confirm its presence.

Accordingly, for bulk facilities in general, Nuclear Material Accountancy is established as a safeguards measure of fundamental importance, or more specifically, material balance verification based on random sampling.

In a simple form the material balance equation reads:

MUF = BI + R - S - EI, where: BI = beginning physical inventory; R = all receipts during MB period; S = all shipments during MB period; EI = ending physical inventory; MUF = material unaccounted for.

MUF can occur because of process holdups, operator measurement errors, losses during processing and, last but not least, as a result of diversion. The establishment of a material balance is necessary for the plant operator, primarily because of economical viewpoints, and, secondly because of requirements and obligations arising from the operating license. From the Agency's point of view, MUF could be an indication of possible diversion.

The use of MUF as a statistical indicator for safeguards is only meaningful if two conditions are met:

- If all components of the material balance equation are subject to independent verification by the Agency.
- If the error limits of MUF (= itself a statistical value) can be determined. Of course, if these limits are exceedingly high, they will again prohibit a statement on the significance of MUF.

In practice, at our LEU model facility, the verification of beginning and ending inventory (PIVs) will be no problem; however, regarding the verification of increases and decreases (i.e. flow verification) we do run into problems. The limited financial resources of the Agency do not allow the presence of Agency inspectors for flow verification whenever inventory changes occur. Therefore, without going into details, it can be stated that with regard to LEU in fuel fabrication plants, the safeguards approach adopted by the Agency is a certain compromise of basic detection goals (remember significance, timeliness, etc). A limited inspection scheme is being implemented using intermittent inspections for flow verifications on a random basis as practicable. In addition, provision will be made in the facility attachment for "strategic points" to allow inspector access to specified locations within the facility for the purpose of obtaining operating data and establishing the operator's measurement uncertainty which are necessary for material balance verification and evaluation.

IV. INSPECTION PROCEDURES

We could say that a number of comprenhesive or less comprehensive safeguards measures such as nuclear material accountancy or containment and surveillance, as applicable, form the basic safeguards approach. These measures require the performance of inspection activities; these activities in turn require a certain infrastructure. In the facility attachment is where this infrastructure (MBAs, KMPs, records-reports system, etc.) is described and where the provisions for inspection implementation (inspection frequency, inspection effort, scope of inspections) are defined.

The structure and content of facility attachments has been discussed elsewhere. Here I will only refer to those codes of the facility attachment which are of particular interest for the inspection activities at our model LEU fuel fabrication plant. You may wish to consult Annexes C (codes 3.1, 3.2 and 3.3); D (codes 5.1 and 5.2) and E (codes 7.1, 7.3, 7.4, 7.5 and 7.6).

A. Inspection Planning

Our verification period is one year according to our timeliness criteria of one year for LEU. Within this period the Agency's inspection activities have to be allocated. For planning purposes the inspectors use form RS1, see Annex F, which lists the Agency's standard inspection activities.

The very first step of our inspection procedures, therefore, is the "Inspection Planning", i.e. defining the periods covered by inspection activities and the intensity or scope of an inspection (audit only or in conjunction with a physical verification).

B. Inspection Frequency

Assuming that operator's accuracy for the Material Balance Closing (σ_{MUF}) meets international standards (at present for LEU fabrication plant $\sigma = 0.3\%$) and assuming a goal to detect the protracted diversion of 1 SQ per year (75kg) with a 90% confidence level, only one PIV will do the job up to a throughput of

$$T = \frac{75 \times 10^{-3}}{3(\%) \times 3.29 \times 0.3(\%)} = 250t \text{ U/year.}$$

This is far below the nominal throughput (400t) of our model plant. Nevertheless, the Agency decided to verify only one of two operator's PITs per year provided for in the facility attachment. State's reports (PILs, MBRs) on both PITs are received and evaluated by the Agency. Intermittent routine inspections, with approximately 1 month intervals, are scheduled usually using 2 inspectors for 2-3 days and 5 to 7 inspectors for several days during the annual PIV.

In order to economize on the time available, I intend to touch on only 3 more topics of inspection procedures as practically implemented at the model plant:

- Examination of records.
- Aspects of verification of the quality of operator's measurement system.
- Physical verifications (flow and inventory).

C. Examination of Records

The activity of primary importance during all inspections is the examination of the accounting records and their reconciliation with operating records. The facility keeps a General Nuclear Material Ledger, a journal type ledger, where any transactions are recorded specifying the date, transfer number or batch name, type of inventory change, material description code, number of items and material quantities. Individual entries in the ledger are checked for arithmetical correctness and consistency with source documents, such as originals of transaction documents, shipping lists, weighing protocols and analytical reports. As in conventional financial accounting, the thesis on which this approach is based is that while one or several documents may be falsified, the probability of successfully falsifying all documents is small and diminishes as the number of documents increases.

Discrepancies detected during the audit activity are discussed with the operator and corrections made as applicable. All discrepancies are recorded by the inspector and included in the inspection report; unresolved discrepancies will be listed in the relevant statement.

Usually the inspector receives a copy of the facility ledger, so that he can mark the checked entries and make notes; it serves the purpose of comparing these facility records (ledger) with the reports (ICRs) submitted by the State to the Agency at a later date.

Based on the audited ledger, the inspector establishes a book figure for the material on site as of a given date, e.g. end of month or date of PIT. This book figure is the operator's commitment for which he accepts responsibility.

D. Verification of quality of operator's measurement system

Any physical verification of nuclear material automatically includes the collection of information on the operator's measurement system. For example, samples for destructive analysis are taken and results compared with operator's data; scales are recalibrated using Agency standards and compared with design information, etc. Here I would like to mention a specific activity carried out at the rod loading station. The accountancy data used for fuel rods are of primary importance at our plant; they consist of analytical data for U-factor, U-235 enrichment and weight data. They originate in the pelletizing area of our plant and when loading pellet columns into the rods. The inspector then witnesses the loading process, calibrates the scales used for this purpose, records the weight data and takes pellet samples for destructive analysis of the pellet lot in process. The results are evaluated by paired comparison with operator's declared production data or design data.

The data collected during inspection over a longer period of time (one or more material balance periods) allow the inspector to derive his own estimate of the operator's measurement uncertainties. He needs these estimates to perform his own evaluation of MUF as stated by the operator and to draw conclusions regarding the significance of MUF. The operator's overall measurement capability affects the inspection effort spent by the Agency at the model plant (refernce is made to paragraphs 7 and 31 of INFCIRC/153).

E. Flow verification

According to the Agency's Safeguards Glossary, flow verification is an activity conducted to confirm a recorded increase or decrease (in terms of batches) of nuclear material in a material balance area. The principal reason for inventory change verification is that the uncertainty associated with these changes can represent a large part of the uncertainty in the material balance equation; this is not so much due to the poor measurement capability for flow items but rather to the amount of material involved. For our model plant, the inventory is only a fraction of the material involved in flow (or compared to the throughput).

- Our model plant receives LEU in the form of UF_6 in large cylinders. During each inspection, the inspector first audits the relevant nuclear material ledger entries, after having received a list of all UF_6 cylinder receipts since the previous inspection. Some cylinders (probably the major part) will have gone into the conversion process already. From the remaining population, the inspector randomly selects a few cylinders for physical verification. Based on historical data for the UF_6 stratum, a statistical sampling plan is prepared and sample sizes computed; at the closing of the material balance, it is compared with the actual number of cylinders verified and retroactively the confidence level for this verification may have to be adjusted. The verification is done by NDA enrichment measurements by means of a Ge/multi-channel analyser system. The measurements are corrected for attenuation through the cylinder walls, the thickness of which is measured with an ultrasonic device. A subsample of the measured cylinders is selected for taking a UF_6 hydrolysis sample for destructive analysis in the Agency's laboratory where the enrichment is determined by mass-spectrometry. These very samples are used as reference standards for calibrating the instrument and correcting the results.

In addition to NDA, the cylinder gross weights are measured using a load-cell based weighing system which has been developed by the Brookhaven National Laboratories and subjected to Agency field tests; the results were encouraging. The system, as well as the tests, are described elsewhere. All data are carefully recorded on inspector's data sheets, Annex G.

There are certain limitations; first, the selection of the sample is not random since the inspector only has access to a small part of the UF_6 population; second, the U-factor cannot be verified since the Agency's laboratories cannot process UF_6-gas samples, and third, the weight verification is restricted to gross-weight verification.

- The final product of our model plant are LWR assemblies. The finished assemblies are temporarily stored in hangers before being packed in shipping containers. NDA measurements are performed using the Neutron Coicidence Collar. The sensitivity of the instrument enables detection of the removal or subsitution of 3-4 rods in a PWR assembly; the measurements have to be complemented by measurements of the active length of the assemblies. The evaluation of the results obtained so far is in process.

  In some cases, it is possible to witness, after the NDA measurement, the packaging of the assembly into the shipping cask and attach a seal; the Agency can then at least confirm the receipt at the power station.

  However, it is not yet possible to verify an assembly and attach a permanent seal which would follow the assembly throughout its lifetime; such seals are not yet available.

- A peculiarity of our model plant is that intermediate products, namely sintered pellets, are shipped out of the plant. The pellets are loaded onto trays, a number of trays are loaded into wooden boxes, and a few boxes are packed into 50 gallon drums for shipment.

  The verification consists of weighing trays of pellets and sampling pellets for destructive analysis to determine the U-factor and U235 enrichment. It has been possible to witness packaging into drums and attach Agency seals for verification at the recieving facility.

F. Inventory Verification

Frankly speaking, a successful PIV is to a large degree an organizational task. At first glance, a PIV carried out by a team of inspectors, in our case probably 5 to 7, seems to be a rather plant intrusive undertaking. An operator will try to minimize the loss of production time; the inspector, on the other hand, is forced to take a snapshot of the plant's situation in terms of nuclear material inventory. A PIV requires careful planning usually months ahead of time. In our case, the Agency's PIV will coincide with the operator's PIT; as a matter of fact, it will "somehow" be carried out "simultaneously". I am inclined to continue by giving the sequence of necessary actions, rather than describing them in detail. I invite you to ask questions where the information provided is not sufficient.

<u>1. Inspection Team</u>. We assume 5 inspectors, one being the coordinating inspector; preferably 2 inspectors should be specialized in NDA methods, 2 in destructive analysis and bulk handling procedures and 1 conversant with records auditing.

<u>2. Time schedule</u>. A matrix is prepared and agreed upon with the operator, showing which material strata (or plant areas) would be due for verification, on which day and by which team, when the inventory lists can be expected, how much time may be used for a stratum, when material movements are expected to be resumed, etc.

For a full PIV, the inspector will have expected the operator to have stopped production and to have cleaned out the plant. Nuclear material should have been accumulated into a few previously agreed inventory KMPs; the material should have been stratified, and lists of the items in each stratum prepared by the operator. Some of these prerequisites may turn out to be unrealistic; but nevertheless the inspector(s) must not compromise their inspection goals.

<u>3. Sampling Plan</u>. A statistical sampling plan is used to select a random subset of items for verification. Two sample sizes, one for attributes and one for variables measurements, are computed (see Annex H). Our inspection goal quantity M is the minimum quantity of nuclear material which, if diverted, could be detected with a 95% probability by assuming a verification accuracy goal (as % of throughput) equal to or comparable with the expected operator's measurement uncertainty.

Example: $T = 440\text{t}$]
$E = 3\%$] $= 12000\text{kg U235}$

$$M = K \cdot \sigma \cdot T$$

$K = 3.3 \rightarrow \gamma = \beta = 0.05$

σ = verification accuracy goal (= 0.3% for LEU fuel fabrication plant)

$$M = 3.3 \times 0.003 \times 12000$$
$$\approx 120\text{kg}$$

Our goal quantity M is larger than 1SQ for our model plant; it implies that nuclear material accountancy (basis of our safeguards approach) is limited by measurement uncertainty.

Historical data from previous material balance periods (or PIVs) will be used to compute preliminary sample sizes for individual strata.

<u>4. Stratification</u>. In theory, i.e. according to the provisions of the facility attachment, the operator prepares, as a result of his PIT, an itemized list of the inventory (IIL), stratified and generally organized by material composition and by internal material control areas. By looking through Annex C, you may have realised that the inventory KMPs of our model plant do indeed represent a stratification scheme; material belonging to one stratum may be found at different plant locations.

The next task is to calculate N and $\bar{x}$ for all strata, compute sample sizes n_a and n_v and assign consecutive numbers to inventory items as the basis for subsequent random selection. A programme developed for HP-97 is used to compute sample sizes and generate random numbers.

I ought to mention here that in reality a straightforward stratification of IILs and subsequent sample size calculations may not be possible, either because the IILs are issued according to areas regardless of stratification criteria, or because strata are distributed over several areas, or because the stratification criteria are not met. Such a situation may require a rather unconventional approach for statistical sampling and verification. We may discuss this further during the workshop sessions.

5. Sampling. In this context sampling means selection of items for sampling. The size of the inventory and number of items do not permit a complete 100% verification of the item population. The mere inspection goal of detecting missing items can be attained equally well and with a satisfactory confidence level by employing a "heavily designed" attributes sampling plan. Exceptions to this are strata with a significant average item size (such as UF_6 cylinders and assemblies). The items selected for attributes testing are marked on the IILs, let's say in blue, a subsample is selected for variables testing and marked with an additional colour. The IILs are, of course, kept by the inspector as one of the fundamental PIV documents; they are part of the working papers attached to the inspection report.

6. Verification. The Agency's verification starts immediately after completion of the PIT; the inspectors work in parallel with several teams, each one being accompanied (supported) by operator's personnel. Usually item selection then has to be completed within the first day, items for variables testing are sealed (paper seal) until verification during the following day(s).

The following attributes methods are used individually or in combination, as appropriate, in order to detect gross defect items:

- weighing (gross).
- NDA qualitative.
- visual examination.
- UF_6 cylinders filled to the top by knocking.

The variables methods employed should serve to detect partially defective items and biases respectively:

- weighing (gross, tare, net).
- sampling for destructive analysis (bulk items only).
- NDA (bundles).
- rod scanner and downloading.

Any verified items (attributes or variables) are recorded on data sheets, Annex I. The careful and complete recording of verification data is a prerequisite for a successful PIV evaluation (post inspection activity) and closing of the material balance.

Our past experience has shown that the inventory, as it is found at the model plant, is accessible and verifiable; adequate verification techniques are available to the Agency. It is, of course, true that the verification of some parts of the inventory is associated with a relatively large uncertainty, either because of the verification technique (NDA for assemblies) or because of the type of material (scrap, waste).

7. Audit. It is obvious that the auditing of records and the establishing of an updated book value (BE) for the nuclear material on the inventory are important parts of any PIV; the BE figure is the operator's commitment which is made prior to physical verification by the inspection team.

The operator's assistance is required and extensively used during the whole PIV. The location of items randomly selected from the IILs is done by plant personnel who are familiar with every corner of the plant. Even though consecutively numbered stickers are attached to items during PIT, it is often a puzzle to find one item. The taking of samples for destructive analysis (pellets, powders, etc.) is done by plant personnel upon request of the inspector; packaging of samples, and, later on, shipment is also the responsibility of the operator. Occasionally, operator's instruments are used by inspectors, e.g. SAM-2 enrichment meters, rod scanners, scales, tumblers, etc.; operator's personnel will operate the equipment witnessed by inspectors.

V. STATEMENTS

Finally, a few words regarding the statement. At the beginning, I mentioned the "end product" of the Agency's safeguards activities. Let me quote paragraph 254 of the Agency's Safeguards Glossary: "Statement, an official communication by the Agency to a State, indicating the results of an inspection carried out in the State or the conclusions the Agency has drawn from its verification activities".

Usually, "Summary Statements" (i.e. results of inspection) are "produced" after each routine inspection; "Conclusion Statements", under an NPT safeguards regime, are only made after a PIV, i.e. when closing the material balance. The preparation of statements requires substantial "post-inspection" activities; the inspection data need to be evaluated and the results have to be analyzed for their safeguards signficance. Let me simply list a few steps of these activities:

- Stratification of FLOW and INVENTORY, over whole material balance period.
- "Paired comparison" of operator-inspector data for verified items, resulting in error estimation and average item differences.
- Error preparation techniques applied for Flow and Inventory strata.
- Compute MUF_{op}, σ_{MUF-op}; $\hat{D}$, $\sigma_{\hat{D}}$,
  MUF_{Ag}, σ_{MUF-Ag};

- Test MUF values for statistical significance; illustration in a bar chart.
- Test MUF values for safeguards significance (relative to SQ or M).
- Check σ_{MUF} against expected international standards for measurement uncertainty.
- Check for adequacy of detection sensitivity, i.e, $\overline{\sigma}_{(MUF-\hat{D})}$ versus M?

As mentioned earlier, the careful recording of inspector's findings (data, differences, discrepancies) is compulsory since the quality of the input data determines the quality of the evaluation results.

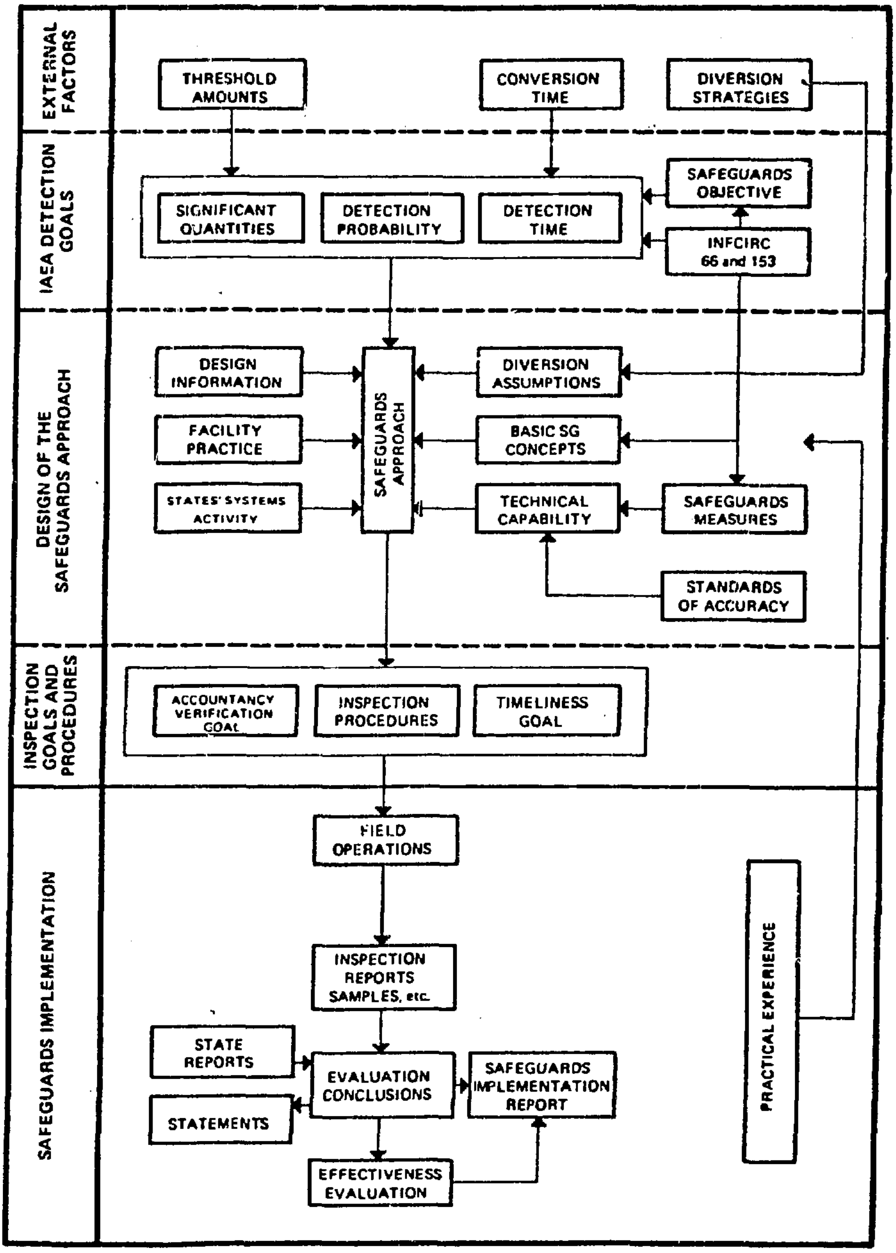
I presume that the actual structure and content of the statements was discussed earlier.

VI. CONCLUSION

I would like to conclude by saying that Agency inspection procedures are always designed in a way as to impose the minimum possible burden on the plant operator. However, it should be recognized that this requires in general a well functioning State system of accounting for and control of nuclear material, as well as a high degree of operator-inspector cooperation and mutual understanding.

ANNEX A

Design of Safeguards Approach



ANNEX B

Diversion Possibilities	Concealment Methods	Safeguards Measures
- Removal of natural or enriched uranium in bulk form	- failure to record receipts	- comparison of reports
	- understating amount received	- weighing, sampling and analysis of random selection of drums received
	- inflation of measurement uncertainty	- IAEA standards
	- substitution with natural or depleted uranium (for enriched uranium)	- analysis of SRDs - seals - NDA measurements
	- borrowing from other facilities	- simultaneous inspections
	- hollow or low density pellets	- weighing - NDA measurements
- Removal of Fuel Assemblies	- changing serial number of assembly and offering for re-inspection plus substitution with dummies	- seals - verification upon receipt at reactor
	- invention of shipment	- careful checking of records and item counting
	- borrowing from other sites	- simultaneous inspection
- Removal of Nuclear Material from Rods and Assemblies	- physical removal from rods and assemblies	- weighing - NDA measurements
- Diversion of scrap pellets	- inventing shipments and inflating amounts shipped (if separate recovery plant)	- thorough checking of records and on-site verification at recovery plant
	- inflation of measurement uncertainty	
	- inflated processing losses	

3.			Safeguards measures
3.1		29	Accountancy
3.1.1		46(b)	Material balance area and identification codes. The whole fuel fabrication plant is one material balance area MBA This MBA includes the entire plant, storage of nuclear material (feed, product, scrap and waste), production processes for the conversion and fabrication of LEU fuel, scrap recovery, and laboratories.
3.1.2		46(b) 37, 38	Strategic points which are key measurement points (KMPs). (For their specifications see Code 4.) */ (a) For determination of nuclear material flow:
	6.3		KMP1 - Receipts, de-exemptions and accidental gains.
3.1.2 (cont'd)	3.5, 3.7 6.2, 7.1		KMP2 - Shipments, exemptions and accidental losses. KMP3 - Uranium blending (material category changes only). KMP4 - Measured discards. KMP* - SR differences and transfers of material to process. - This is a KMP in which all SR differences must be recorded and reported even if numerically zero. - All material received in KMP1 is considered to be in process as of the date of recording the SR difference. (b) For determination of physical inventory: KMPA - UF6 cylinders and heels. KMPB - Unsintered UO2 powder and pellets. KMPC - Sintered UO2 in pellets and hard scrap. KMPD - Fuel rods. KMPE - Fuel assemblies. KMPF - Scrap (ADU, grinder sludge, and dirty powder). KMPG - Solid waste (barrels and filters). KMPH - Liquid waste (plant effluents). KMPI - Nuclear material in small quantities each containing less than 0.01 effective kilograms, such as laboratory, QC archive samples, etc. KMPJ - Other nuclear material not included in KMPs A through I.

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*/ These KMPs include the locations, within the facility, where instrument readings and measurements, relevant to the source data, are made wherever and whenever these source data are generated.

3.1.3	46(c)	Physical inventory taking. Nominal frequency for physical inventory: Semiannual. Procedures: As described in the design information for the Exxon nuclear fuel fabrication plant. A stratified list is compiled in preparation for the Agency's verification of the physical inventory taking showing on the basis of the information in the facility's records, the anticipated number of items in each stratum and the description and location of the items such as drums, trays, rods and assemblies, etc. The list shows nominal values in the weight of compound, element content and enrichment for the items in each stratum.
3.2	29	Containment and surveillance
3.2.1	46(f)	Strategic points for the application of containment and surveillance measures: Storage and process areas as appropriate.
3.2.2	73(d)(e)	Installed Agency instruments and devices: (i) - Seals on fuel assemblies; (when available and mutually agreed). - Seals on shipping containers of product material subject to IAEA safeguards at the receiving facilities. - Seals on Agency sample containers. - Seals on Agency standards. - Seals on Agency installed devices including measurements and surveillance equipment. - Seals used for physical inventory verification purposes during the verification time. - Surveillance equipment (e.g. for detection of unrecorded movements of nuclear material during P.I. verification if agreed by the - Seals on items to be re-shipped on shipper's value.

If the operator needs to remove a seal or to interfere with the operation of safeguards instruments as listed above, the Agency shall be informed in advance by the fastest means. The information shall include the probable date on which the removal of the seal or the interference with the safeguards instruments will take place. If a seal is removed in the absence of an Agency inspector without the operator being able to inform the Agency in advance, a special report will be prepared as specified in Code 6.4.1.

(ii) Seals may be broken by the operator if needed without advance notification:

- On nuclear material which could be left sealed up to the next physical inventory verification.
- On containers with input material received in KMP1 sealed upon receipt.

3.3			<u>Additional strategic points</u> Inventory KMPs (3.1.2 (b)) are also considered strategic points for access at other times than the P.I. verification.
3.4	6.1	11, 35	<u>Specific provisions and criteria for termination of safeguards on nuclear material</u> Safeguards on measured discards will be considered to be terminated upon receipt by the Agency of the inventory change reports pertaining to such discards if less than 0.3 effective kg are involved in a 6 month period. In the case of discarding quantities of uranium exceeding 0.3 effective kg in six months, the Agency shall be consulted before such discarding takes place.
3.5	6.2	36, 37	<u>Specific provisions and criteria for exempting nuclear material from safeguards</u> None.

Code	General Part Reference (Codes)	Agreement Reference (Articles)	
4.3			Additional strategic points; source and operating data Source/operating data as for inventory KMPs.
5.	3.5, 3.7	46(d), 49	Records System
5.1	2.1.2	54, 32(f)	Specific provisions for accounting records
5.1.1		54(a)	Inventory changes (for the specifications of source data see Code 4.1 above), time of recording:
			- Receipt (KMP 1): Upon receipt.
	6.3		- De-exemption (KMP 1): Upon the accounting transfer of the nuclear material.
			- Accidental Gain (KMP 1): Upon determining the amount of the gain.
			- Shipment (KMP 2): Upon shipment.
	6.2		- Exemption (KMP 2): Upon the accounting transfer of the nuclear material.
	7.1		- Withdrawal (KMP 2): Upon withdrawal.
			- Accidental loss (KMP 2): Upon determining the amount of the loss.
			- Uranium blending (KMP 3): Upon blending.
			- Measured discard (KMP 4): Upon discard.
			- SRD (KMP*): Upon measurement by the operator of the material received and recorded on shipper's data.
5.1.2	2.1.1	54(b)	Measurement results used for determination of the physical inventory (for the specifications of source data see Code 4.2 above), time of recording:
			- For all inventory KMPs: Upon identification and measurement as applicable.

Code	General Part Reference (Codes)	Agreement Reference (Articles)	
5.1.3	2.1.2	54(c)	Adjustments and corrections, time of recording: - MUF: After a physical inventory has been taken. - Corrections (all KMPs): (a) Whenever errors have been found; (b) When the results of a more precise measurement have become available; or (c) Whenever measurement bias has been observed.
5.2	2.1.2	56	<u>Specific provisions for operating records</u>
5.2.1		56(a)	Operating data used to establish changes in the quantities and composition of nuclear material: - Location of the nuclear material as described in the design information. *- The fuel rod loading stations: Date and the relevant source data (see Code 4.1) for each fuel rod loaded. *- Information on any accident which results in a loss of nuclear material. *- The assembling stations for fuel assemblies: Date and the relevant source data (see Code 4.1) for each assembly. - The list of seals removed by the operator. *- Blending operations will be described with the information on quantities of material used for blending. - Compound quantities, nominal U-factor and nominal U-enrichment for each powder and pellet lot.
5.2.2		56(b)	Calibration of tanks and instruments, sampling and analysis, procedures to control the quality of measurements, derived estimates of random and systematic error: - All KMPs: (a) Date, method of calibration, original calibration data and calibration results for all measurements used for purposes of nuclear material accounting, including equipment for measuring weight, volume, density, uranium, U-235 and impurity content.

Code	General Part Reference (Codes)	Agreement Reference (Articles)	
5.2.2 (cont'd)			(b) Date, procedure, data and derived estimates of random and systematic errors associated with measurements for nuclear material accountancy, including errors associated with weighing, volume determination, density determination, sampling analysis of uranium and U-235 content, calibration, and other relevant error sources. (c) Date, procedure, data and results of analyses of standards and process samples used to control the quality of measurements in nuclear material accountancy. (d) Date, type of material sampled, method of sampling, name or number of batch, weight or volume of each sample taken and its destination. (e) Date and method of the analyses of each sample taken, data and results of analyses and obtained measurement precision. (f) Information on any malfunctioning of the measurement equipment.
5.2.3		56(c)	Sequence of the actions taken in preparing for and in taking the physical inventory: - All physical inventory KMPs: Dates and description of the actions taken and the results obtained. An itemized list, stratified and generally organized by material composition and by internal material control areas after completion of inventory taking by the operator.
5.2.4		56(d)	Actions taken in order to ascertain the cause and magnitude of any accidental or unmeasured loss: - Date and description of the actions taken and the results obtained.

Code	General Part Reference (Codes)	Agreement Reference (Articles)	
6.4.2			Contents in relation to Code 6.4.1 (a): - Date when the incident or circumstance occurred. - Description of the actions taken in order to ascertain the cause of the incident or circumstance and the magnitude of the loss. - Cause and features of the incident or circumstance. - Estimated amount of nuclear material which has been lost.
7.	4.2		Inspections
7.1		78, 82	Mode of routine inspections Continuous during physical inventory taking; Intermittent otherwise.
7.2		78	Applicable formula and procedure for determination of maximum routine inspection effort Article 78(b) or (c) as applicable.
7.3		76, 79	Indication of the actual inspection effort under ordinary circumstances An estimate of the actual routine inspection effort, as far as can be foreseen and assuming:
	3.1		(a) Circumstances at the facility to be as described in the information provided in respect of the facility; and
	2.		(b) The continued validity of the information on the national system of accounting for and control of nuclear material as set out in the General Part of the Subsidiary Arrangements. 100 - 120 man-days per year for normal production.

ANNEX E

Code	General Part Reference (Codes)	Agreement Reference (Articles)	
7.4		72, 73	Indication of the scope of routine inspections under ordinary circumstances
7.4.1			General: - Examination of the records, verification for self-consistency and consistency with reports. - Observation of the calibration of scales and other nuclear material measuring equipment used for accounting purposes, including the calibration of scales by means of weights standards provided by the Agency. - Verification of the quality of the operator's measurement system including analytical and NDA equipment using independent standards. - Taking representative analytical samples from complete population. - Other activities as appropriate.
7.4.2			At flow KMPs:
	9.4		- Observation of weighing; - Selection of items to be sampled for the Agency and observation of sampling (see Code 7.6 below); - Observation of the treatment and analyses of accountability samples; - Application, examination, removal and exchange of Agency seals provided for under Code 3.2.2; - Identification and counting of the fuel assemblies and rods; - Non-destructive measurements using the Agency's portable instruments; - Use of operator's solid waste assay system, and enrichment control instruments (e.g. rod scanner and SAM 2) when feasible.
7.4.3			At inventory KMPs: - Verification of the operator's physical inventory taking for completeness and accuracy; - Weighing of containers with bulk materials and pellets on a random basis in accordance with the Agency's sampling plan; - Selection of items to be sampled for the Agency in accordance with the Agency's sampling plans and observation of sampling; - Identification of and counting the fuel rods and assemblies in accordance with the Agency's sampling plans; - Use of the Agency's portable instruments for non-destructive measurements; - Use of operator's solid waste assay system, and enrichment control instruments (e.g. rod scanner and SAM 2) when feasible; - Application, examination, exchange or removal of Agency seals.
7.4.4			At additional strategic points: - As listed above for the corresponding inventory KMPs as appropriate.

ANNEX F

INSPECTION PLAN . (RS/1)

1.1 IDENTIFICATION OF INSPECTION AND INSPECTORS

Section	Country	Facility Code	Year	/ Rep. No.	Ref. No.	Last day of previous Inspection

V	R	A	S					
Inspection Type				Date from	Date through	CDI	Md/153	Total No. of MBA at the Facility

INSPECTION TO BE CONDUCTED BY THE FOLLOWING INSPECTORS (the first name is the coordinator)

1.	2.	3.	4.	5.	6.
7.	8.	9.	10.	11.	12.

1.2 INSPECTION ACTIVITIES TO BE PERFORMED AT MBA(s)

1-1	Follow-up actions	Y	N			
1-2	Accounting Records Examination	Y	N	Date from	Date through	
1-3	Operating Records Examination	Y	N			
1-4	Accounting and Operating Records Reconciliation	Y	N			
1-5	Records and Reports Comparison	Y	N	Date from	Date through	
1-6	Book Inventory Up-dating	Y	N	Date from	Date through	
1-7	Verification of the Inventory Changes	Y	N	Date from	Date through	Verification Method A B C D E F G Z
1-8	Verification of Inventory	Y	N	Type of Verific. Ph I	As of	Verification Method A B C D E F G Z
1-9	Verification of quantities at the strategic points that are neither *KMPs nor strategic points for C/S*	Y	N	Date from	Date through	Verification Method A B C D E F G Z
1-10	Surveillance Application	Y	N	TV activity I S R C		MC I S R C
1-11	Seals Application	Y	N	Attach. Detach. Replace Check		
1-12	Verification of adequacy of the operator's measurement system	Y	N			
1-13	Evaluation in respect of the SRD's, accidental losses, MUF and measured discards in excess of specified limits	Y	N			
1-14	Other Activities	Y	N			

Use of Inspection Equipment	Y	N				Other
			Type of equipment			

Explanatory Notes	Y	N	Attachment(s)	Y	N

Prepared by ____________ / ____________ / on ____________
Name Signature

Clearance: Section Head ____________ on ____________
Signature

If necessary: Director ____________ on ____________

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MB-1. / UF_6: NDA + WEIGHING + SAMPLING

MBA:
INSPECTION DATE:

INSPECTION REPORT NO.:
REFERENCE NO.:

INSPECTORS:

Date Time	Cylinder No.	Peak Integrated (channels)	Counts/1000"	Counts/200" Im	$n=\frac{E(\%)}{C_{200}}$	Wall Thickness d [mm]	E(%)-measured	OPERATOR		G T N	OPERATOR Weight Data	IAEA [load-cell]		Additional Info. (Sample No., ...
							$E=Im\cdot e^{1.12262\cdot d}\cdot n$	E(%)	C(%)			Reading	Corrected	
	Standard KM0042													
	Standard 2.9456%													
	Standard 3.8197%													
	Standard 4.9550%													

SAMPLING PLAN

$$n_i = N_i\ (1-\beta^{\gamma \bar{x}_i/M})$$

where:

n_i - sample size for the stratum i

N_i - number of items in stratum i

$1-\beta$ - diversion detection probability (for 95% det. prob. $\beta = 0.05$)

γ - Coefficient of fractional falsification of item size according to operators diversion approach ($\gamma \leqq 1$)

$\bar{X}_i$ - average fissile weight per item (kg)

M - goal quantity for this facility (inspection goal quantity, $M = k \times \sigma \times A$)

MBA:
INSPECTION DATE:

AREA CODE:
MAT. CAT. (E/N/D/T):

INSP. REP. NO.:
REF. NO.:

INSPECTOR(S):

ITEM-IDENTIFICATION (Tag No. plus Container ID. No.) Important!!	OPERATOR - DATA						IAEA - VERIFICATION							REMARKS (e.g. # of Sample, difficulties, etc.)
	Gross-Wt.	Tare-Wt.	Net-Wt.	C (wt%)	E (%U5)	Mat.-Descrip. (Code or Name	Verif.-Method						Verification-Results (weights or NDA count etc.)	
							T	B	D	E	F	Z		