

International Target Values 2000 for Measurement Uncertainties in Safeguarding Nuclear Materials

H. Aigner, R. Binner, E. Kuhn
IAEA, Vienna, Austria

1. INTRODUCTION

The IAEA has published a revised and updated version of International Target Values (ITVs) for uncertainty components in measurements of nuclear material^[1]. This represents the fifth revision of the original release of such tables issued in 1979 by the ESARDA/WGDA. The ITVs represent uncertainties to be considered in judging the reliability of analytical techniques applied to industrial nuclear and fissile material subject to safeguards verification. The tabulated values represent estimates of the "state of the practice" which ought to be achievable under routine conditions by adequately equipped, experienced laboratories. The most recent standard conventions in representing uncertainty and reliability data have been taken into account, while maintaining a format which allows comparison to previous releases of ITVs. The ITVs 2000 are intended to be used by plant operators and safeguards organizations as a reference of the quality of measurements achievable in nuclear material accountancy, and for planning purposes. They may also be used for statistical inferences regarding the significance of operator-inspector differences whenever insufficient measurement data is available.

The IAEA prepared a draft of a technical report presenting the proposed ITVs 2000, and in April 2000 the chairmen or officers of the panels or organizations listed below were invited to co-author the report and to submit the draft to a discussion by their panels and organizations.

- Euratom Safeguards Inspectorate
- ESARDA Working Group on Destructive Analysis
- ESARDA Working Group on Non Destructive Analysis
- Institute of Nuclear Material Management
- Japanese Expert Group on ITV-2000
- ISO Working Group on Analyses in Spent Fuel Reprocessing
- ISO Working Group on Analyses in Uranium Fuel Fabrication
- ISO Working Group on Analyses in MOX Fuel Fabrication
- Agencia Brasilenno-Argentina de Contabilidad y Control de Materiales Nucleares (ABACC)

Comments from the above groups were received and incorporated into the final version of the document, completed in April 2001. The final report replaces the 1993 version of the Target Values, STR 294.

2. HISTORY

Safeguarding nuclear material involves a quantitative verification of the accountancy of fissile materials by independent measurements. In the absence of relevant international standards of measurements, the International Atomic Energy Agency (IAEA) had defined in the 1970s a set of international standards of nuclear material accountancy, which listed the "expected measurement accuracy associated with the closing of a material balance" at five different types of nuclear facilities. However, these values have never been reviewed despite numerous technological changes since their adoption by consensus by a group of experts designated by their Governments. Safeguards officials and evaluators but also plant measurement specialists needed more current and informative references regarding the performance capabilities of measurement methods used for the determination of the volume or mass of a material, for its sampling, its elemental and isotopic assays.

The Working Group on Techniques and Standards for Destructive Analysis (WGDA) of the European Safeguards Research and Development Association (ESARDA) pioneered the way in 1979 by presenting a list of "Target Values" for the uncertainty components in destructive analytical methods^[2] to the safeguards authorities of Euratom and of IAEA. Revised estimates were prepared in

collaboration and published as the 1983 Target Values^[3] after four years of extensive discussion and consultation with and within operators' laboratories and safeguards organizations. The international acceptance of the concept grew further with the next review, which involved, besides the ESARDA/WGDA and IAEA, the active participation of the members of two specialized committees of the Institute of Nuclear Materials Management (INMM). The 1987 Target Values, published as a result of this review^[4], defined, like the previous editions, the values of “random” and “systematic” error parameters to be aimed for in elemental and isotopic analyses of the most significant types of materials using common destructive analytical methods. The same groups took a new step when they agreed to define with the 1988 edition^[5] the values of the random error parameter to be met in the elemental assays as a result of sampling. Unfortunately, it was not possible at this time to include values for sampling uncertainties arising from systematic effects.

Following a 1988 recommendation of the IAEA Standing Advisory Group on Safeguards Implementation (SAGSI), the IAEA convened a Consultants Group Meeting in June 1991 to provide expert advice on international standards of measurements applicable to safeguards data. A concept of International Target Values (ITVs) was proposed on the model of the 1988 ESARDA Target Values and included estimates of the “random and systematic error” uncertainties originating from the measurements of volumes or masses of nuclear materials. The scope of ITVs was also extended to include a consideration of the non-destructive assay methods (NDA) which had won acceptance as accountancy verification tools.

Specialists from four continents took part in the discussion of the proposed concept. The ESARDA/WGDA held joint meetings with the ESARDA Working Group on NDA methods (ESARDA/WGNDA). The IAEA organized a series of Consultants Group Meetings with the participation of a representative from a large European reprocessing plant, of Brazilian and Japanese nuclear national authorities along with representatives of ESARDA, INMM, the International Organization for Standardization (ISO), the European Commission (EC) and IAEA inspectorates. The result was the publication of an IAEA Safeguards Technical Report in March 1993^[6]. Articles in the ESARDA Bulletin and in the Journal of the INMM widely publicized the IAEA technical report.

3. NOMENCLATURE AND DEFINITION OF UNCERTAINTY COMPONENTS

An effort was made to bring the nomenclature in line with the latest recommendations of ISO^[7], the National Institute of Standards and Technology (NIST)^[8] and the European Association of Chemical Measurements (EURACHEM)^[9]. A clear distinction for example is made between the meaning of the term “error” and the term “uncertainty”. The ITVs 2000 indeed represent target standard uncertainties, expressing the precision achievable under stipulated conditions. These conditions typically fall in one of the two following categories: “repeatability conditions” normally encountered during the measurements done within one inspection period; or “reproducibility conditions” involving additional sources of measurement variability such as “between inspections” or “between laboratories” variations.

Two categories of uncertainties play an important role in planning for inspections and in drawing inferences from inspection data: uncertainties due to repeatability effects, which are of a purely random nature, and uncertainties resulting from systematic effects within a given set of data, corresponding to an inspection period^[10,11]. These uncertainties are designated by the symbols **u(r)** and **u(s)**, respectively:

- **random uncertainty components, u(r)**, are due to errors varying in an unpredictable way among individual items or results. Counting statistics or the repeatability of measurements within a short period of time under constant conditions are typical examples for random uncertainty sources. Simply stated, the effects of random uncertainties can be reduced by repeated measurement, sampling and analysis, but it is not possible to correct for random errors.
- **uncertainty components of a systematic character, u(s)**, are due to errors affecting an entire group of items in the same way, like all measurement results

interpreted with the same calibration curve, normalized with the same normalization experiments, or affected by the same background subtraction. But also uncertainties in the certified values of reference materials, nuclear data uncertainties or constant instrument or laboratory biases will appear to have a systematic character. The effects of uncertainties of a systematic character cannot be reduced by repetition under a fixed set of conditions encountered during a given inspection period. The cause of systematic errors may be known or unknown. If both the cause and the value of a systematic error are known, it can be corrected for, but there will still remain an uncertainty component of systematic character, which is associated with this correction.

A basic assumption is that $u(r)$ and $u(s)$ are characteristics of the type of material, its chemical and physical form and of the method of measurement. A further assumption is that the component of systematic character, $u(s)$, is constant for a given inspection period, but that it varies in a random manner from one inspection to another, for both the operator and the inspector.

4. SOURCES FOR ITVS 2000

The International Target Values 2000 for Measurement Uncertainties (ITVs 2000) are values for uncertainties associated with a single determination result; e.g., this may be the result reported by one laboratory on one sample (independent of the analytical scheme applied internally in the laboratory), or the result of an NDA measurement performed on a single item. The ITVs 2000 take into account actual practical experiences and should be achievable today under the conditions normally encountered in typical industrial laboratories or during safeguards inspections.

As in earlier publications the values listed in the present document have been derived from an evaluation of actual measurement data. Four sources of information were considered. The most relevant and complete set of measurement data still comes from the information gathered by safeguards inspectorates during the statistical evaluation of the results of the measurements reported by the facility operators and the results of independent measurements performed on the same materials by the inspectors^[12,13]. This approach is referred to as the “top-down” approach. These data were complemented and confirmed by “bottom-up” assessments of measurement uncertainty components published by measurement specialists and derived according to the ISO^[7], NIST^[8] and EURACHEM^[9] guides. In addition and whenever possible, it was verified that the proposed ITVs were consistent with the results of laboratory intercomparisons or measurement quality evaluation programmes. In cases where little or no statistical data was available (particularly for sampling uncertainties), some values were defined on the basis of expert opinion.

The ITVs 2000 are applicable to the accountancy data collected by the inspectorates. They do not represent the ultimately achievable performance of a measurement system, which would be obtained under exceptional or ideal laboratory conditions. However, they reflect reasonably well the progress observed during the past several years in the routine performance of measurements done for the purpose of material accountancy and verification.

The ITVs 2000 intend to take also into account all sources of measurement uncertainties, including sources which may not be apparent in Performance Values resulting from paired comparisons of operator's and inspector's measurements.

5. STRUCTURE AND CONTENT OF THE ITVS 2000

The presentation of the 1993 ITVs involved 16 different tables. A different format was chosen for the presentation of the ITVs 2000, which include only 7 tables.

- Table 1 provides a list of the codes used to identify the measurement methods in Tables 2-7.
- Tables 2 to 6 list the ITVs 2000 for bulk and density measurements, sampling, the determination of element concentration, of ²³⁵U isotope abundance, and of plutonium isotope ratios, respectively.

- ITVs for total amount of fissile element or isotope are given in Table 7 for NDA techniques providing a direct measurement.
- Each table identifies separate ITVs according to the type of material and measurement method, as appropriate.
- Two parameters, $\mathbf{u(r)}$ and $\mathbf{u(s)}$, characterize the quality, which should be aimed for in a specific measurement of a given material using a specified method at a single laboratory. These parameters should include all uncertainty components, which determine the potential difference between the measured and the true value.
- It has not yet been possible to propose ITVs for the term $u(s)$ applicable to sampling, except in a few cases, where this parameter was found to be actually measurable. It should also be noted that random sampling errors were frequently not assessed on the basis of experimental data (due to lack of such) and are based on expert opinion and facility experience.
- The combination of the $u(r)$ and $u(s)$ parameters

$$u_c(t) = [u(r)^2 + u(s)^2]^{1/2} \quad (1)$$

is equivalent to the relative combined standard uncertainty of the measurement, as it is defined in the ISO^[7], NIST^[8] and EURACHEM^[9] Guides, when it is applied to the measurement of a single laboratory.

- The ITVs in Tables 2 to 7 apply to situations where the measured quantity is large enough so that the relative uncertainty of the measurement remains essentially constant for the given range of measurements.
- The $u(r)$ and $u(s)$ parameters of bulk measurements, sampling, element concentration and isotope abundance measurements from Tables 2 to 6 must be combined according to equations (2) and (3), in order to obtain the ITVs, $u_c(r)$ and $u_c(s)$, applicable to analytical data resulting from a given combination of several measurement steps.

$$u_c(r)^2 = \sum_l u_l(r)^2 \quad (2)$$

$$u_c(s)^2 = \sum_l u_l(s)^2 \quad (3)$$

where l refers to an individual step of the analytical process,

and $l = 1, 2, \dots, n$

Table 1: Measurement Method Codes

Method /Instrument Code	Technique
ANCC	Advanced Neutron Coincidence Counter
AWCC	Active Well Coincidence Counter
CALR	Calorimeter
COMP	Combined Product Uranium Concentration and Enrichment Assay (COMPUCEA)
DIPT	Dip Tube
EBAL	Electronic Balance
FRSC	Fuel Rod Scanner
GRAV	Gravimetry
GSMS	Gas Source Mass Spectrometry
HKED	Hybrid K-Edge/K-XRF Densitometer
HLNC	High Level Neutron Coincidence Counter
HRGS	Infield High Resolution Gamma Spectrometer
IDMS	Isotope Dilution Mass Spectrometry
INVS	Inventory Sample Coincidence Counter
KED	K-Edge Densitometer
LCBS	Load-Cell Based Weighing System
LMCA	Laboratory Multichannel Analyzer/Hi-resolution GS
LMCN	Laboratory Multichannel Analyzer, NaI-detector
PCAS	Plutonium Canister Assay System
PHON	Photon Neutron Interrogation Device
PMCG	Portable Multichannel Analyzer, GeLi-detector
PMCN	Portable Multichannel Analyzer, NaI-detector
PSMC	Plutonium Scrap Multiplicity Counter
TIMS	Thermal Ionization Mass Spectrometry
TITR	Titration
UNCL	Uranium Neutron Coincidence Collar
VTDM	Vibrating Tube Density Meter
WDAS	Waste Drum Assay System

Table 2: Bulk & Density Measurements

Measurement	Instrument	Uncertainty Component (% rel. Std. Uncertainty)	
		u(r)	u(s)
Mass	LCBS	0.05	0.05
	EBAL	0.05	0.05
Volume ^{1/}	DIPT	0.30	0.20
Density	DIPT	0.30	0.20
	VTDM	<0.05	<0.05

1.) Volume determinations are made on the basis of level pressure, density and temperature measurements. The volume measurement uncertainties are highly dependent on the homogeneity of the liquid, the quality of the density measurements and of the calibration equation determined in the calibration process. The volume measurements may also involve an absolute error component which has to be taken into consideration when determining the overall uncertainty of volume measurements. For accountability tanks in large-throughput facilities, uncertainties of 0.05% for u(r) and 0.1% for u(s) at full volume are achievable if: i.) A carefully designed calibration procedure has been implemented under well-controlled environmental and stable temperature conditions; and ii.) Measurements are performed on a well-characterized and homogenized liquid.

Table 3: Sampling Uncertainties for Elemental Concentration and ²³⁵U Abundance

Material	Uncertainty Component (% rel. Std. Uncertainty)				Recommended Minimum Sample Size ^{5/}
	Concentration		²³⁵ U Abundance		
	u(r)	u(s) ^{1/}	u(r)	u(s) ^{1/}	
DUF ₆	0.10	nd	1	nd	5-10 g
HEUF ₆ & LEUF ₆ & NUF ₆	0.05	nd	0.10	nd	5-10 g
U-oxide Powder	0.20	nd	nd	nd	10-20 g
U-oxide Pellets	< 0.05 ^{2/}	< 0.05	< 0.05	< 0.05	1 pellet
U Scrap (clean) ^{3/}	1	nd	1	nd	30 g
U Scrap (dirty) ^{4/}	10	nd	10	nd	2 x 30 g
Reprocessing Input Sol.	0.30	0.20	< 0.05	nd	2 x 1 ml
U Nitrate Sol.	0.10	nd	< 0.05	nd	10 ml
Pu, U/Pu Nitrate Sol.	0.20	nd	< 0.05	nd	10 ml
Pu-oxide	0.10	nd			2 x 1 g
FBR & LWR MOX	0.70(Pu) 0.20(U)	nd	0.10	nd	2 x 1 pellet or 2 x 2 g (FBR MOX) or 2 x 5 g (LWR MOX)
MOX Scrap(clean) ^{3/}	1	nd	1	nd	2 x 5 g
MOX Scrap(dirty) ^{4/}	10	nd	10	nd	2 x 10 g
U Metal	0.05	nd	< 0.05	nd	1-5 g
HEU Alloys	0.20	nd	< 0.05	nd	5-10 g

1.) Missing values (nd) have not yet been defined.
 2.) 0.20 for Gadolinium-containing pellets.
 3.) Scrap with low impurity content and suitable for direct recycling.
 4.) Scraping errors can vary widely depending on material heterogeneity and sample size.
 5.) According to STR-69¹⁰⁰

Table 4: Element Concentration

Method	Material	Uncertainty Component (% rel. Std. Uncertainty)				Notes ^{1/}
		U-Conc.		Pu-Conc.		
		u(r)	u(s)	u(r)	u(s)	
GRAV	U Oxides(pure),UF ₆	0.05	0.05			2/
	Pu Oxide			0.05	0.05	2/
TITR	U Oxides,UNH,UF ₆	0.1	0.1			
	U Alloys	0.2	0.2			
	Pu Oxide, Pu Nit.			0.15	0.15	3/
	MOX, U/Pu Nit.	0.1	0.1	0.2	0.2	3/
IDMS	U & Pu Compounds					4/5/
	Hot Cell Conditions Glove Box Conditions	0.2 0.15	0.2 0.1	0.2 0.15	0.2 0.1	
KED	U in solution	0.2	0.15			6/
	Pu in solution			0.2	0.15	6/7/
	FBR MOX			0.3	0.2	6/
HKED	Spent Fuel Solution, LWR MOX	0.2	0.15	0.6	0.3	8/
COMP	U Compounds	0.2	0.15			2/6/9/
ANCC	Pu Oxide, MOX			0.2	0.2	10/
INVS	Pu Oxide, MOX			2	1.5	11/12/
	MOX Scrap			10	2.5	11/

1.) Concentration measurements on powders and solutions require weight change correction because of sample instability.
 2.) Material containing non-volatile impurities < 1000 ppm
 3.) Equivalent performance may be expected when applying exsolution
 4.) Materials typically encountered in the nuclear fuel cycle
 5.) Under conditions of sufficiently different isotopic compositions of spike and sample and near-optimum sample:spike ratio(83,96,97)
 6.) Measurement time 1000 sec., adjusted for age of source when necessary
 7.) For samples in solution with >50 g/l Pu
 8.) 150 g/l U, 1.5 g/l Pu
 9.) 200 g/l U
 10.) For 2g sample; 4 hour counting time; isotopic determination by mass spectrometry; detector efficiency > 40%
 11.) Measurement time 300 sec.
 12.) Isotopic determination by mass spectrometry

Table 5: ²³⁵U Abundance

Method	Material	Uncertainty Component (% rel. Std. Uncertainty)		Notes
		u(r)	u(s)	
GSMS	DUF ₆ & NUF ₆	0.1	0.1	
	LEUF ₆	0.05	0.05	
	HEUF ₆	0.02	0.02	
TIMS	DU (< 0.3 wt.% ²³⁵ U)	0.5	0.5	
	U (0.3% < ²³⁵ U < 1%)	0.2	0.2	
	LEU (1% < ²³⁵ U < 20%)	0.1	0.1	
	HEU (> 20 wt.% ²³⁵ U)	0.05	0.05	
COMP	LEU Compounds	0.4	0.2	1/
LMCN ^{2/}	LEU Oxides	0.3	0.3	
	HEU Oxides	0.2	0.2	
PMCN ^{2/3/}	DUF ₆	20	15	4/
	NUF ₆	10	8	4/
	LEUF ₆	5	3	4/
	NU Oxides	5	5	
	LEU Oxides	3	2	
	NU & LEU Scrap (clean) ^{5/}	5	5	6/
	NU & LEU Scrap (dirty)	15	10	6/
	LEU Fuel Rods	2.5	1	
	LEU Fuel Assemblies	2.5	1	
	HEU Metal	0.5	0.5	7/
	HEU Alloys	1	1	7/
PMCG ^{3/}	DUF ₆	15	10	4/
	NUF ₆	8	5	4/
	LEUF ₆	4	2	4/
	LEU Oxides	3	2	
	HEU Metal	0.5	0.5	7/
	HEU Alloys	1	1	7/

1.) Measurement time 1000 sec., adjusted for age of source when necessary; see Ref. [21]
 2.) For materials not containing reprocessed uranium.
 3.) Measurement time 300 sec.
 4.) Includes uncertainty component associated with ultrasonic thickness gauge measurement of the UF₆ cylinder.
 5.) Scrap with low impurity content and suitable for direct recycling.
 6.) Uncertainties for scrap represent average performance observed on historical data. Material matrix heterogeneity is the main contributor to the observed uncertainties and can vary widely.
 7.) Calibration against reference material certified to 0.3 % or better & uncertainties in the correction of container wall absorption of 0.5 % or less.

Table 6: Plutonium Isotope Assay of Pu Oxide and MOX (% Relative Standard Uncertainties)

Material Type	Isotope Ratio	Typical Value for Ratio (*100)	Method					
			TIMS ^{1/}		HRGS ^{2/}		LMCA ^{3/}	
			u(r)	u(s)	u(r)	u(s)	u(r)	u(s)
High-Burnup Pu	²³⁸ Pu/ ²³⁹ Pu	1.7	1.5	1	2	2	1	1
	²⁴⁰ Pu/ ²³⁹ Pu	43	0.1	0.05	1	1	0.7	0.7
	²⁴¹ Pu/ ²³⁹ Pu	13	0.2	0.2	1	1	0.7	0.7
	²⁴² Pu/ ²³⁹ Pu	8	0.2	0.3				
Low-Burnup Pu	²³⁸ Pu/ ²³⁹ Pu	0.02	10	10	10	10	5	5
	²⁴⁰ Pu/ ²³⁹ Pu	6	0.15	0.1	2	2	1.5	1.5
	²⁴¹ Pu/ ²³⁹ Pu	0.2	1	1	2	2	1	1
	²⁴² Pu/ ²³⁹ Pu	0.05	2	2				

1.) ²³⁸Pu/²³⁹Pu by alpha spec./TIMS combination
 2.) Measurement time 3 x 100 sec.
 3.) Measurement time 3 x 1000 sec.; 0.5 g Pu.

Table 7: Total Mass - ²³⁵U & Pu by Direct NDA Measurement Techniques

Instrument	Material	Uncertainty Component (% rel. Std.Dev.)				Notes
		²³⁵ U Mass		Pu Mass		
		u(r)	u(s)	u(r)	u(s)	
AWCC	HEU Metal, HEU Alloys	5	3			1/
	HEU Fuel Elements	3	2			1/
FRSC	U Fuel Rods	1	1			
PHON	LEU Oxides	2	1			
	LEU Scrap	4	1			
UNCL	U Fuel Assemblies	4	2			
HLNC	Pu Oxide Powder			1	0.5	2/3/
	FBR MOX (> 10% Pu)			2	0.5	2/3/
	LWR MOX (< 10 % Pu)			4	1.5	2/3/
	MOX Scrap			10	3	2/4/
	Pu Fuel Rods			1.5	1	2/3/
	MOX Fuel Rods			2	1	2/3/
PCAS	MOX Fuel Assemblies			1.5	1	2/3/
	FBR MOX			1.5	1	3/
PSMC	MOX Scrap			8	2	4/
	MOX Scrap (clean)			2.5	1	3/5/
WDAS	MOX Scrap (dirty)			8	2	4/
	MOX Waste			8	2	4/
CALR	Pu Oxide and MOX			0.4	0.4	3/6/7/

1.) Measurement time 600 sec.
 2.) Measurement time 300 sec.
 3.) Isotopic determination by mass spectrometry and alpha spectrometry.
 4.) Uncertainties for scrap represent average performance observed on historical data. Material matrix heterogeneity is the main contributor to the observed uncertainties and can vary widely.
 5.) Scrap with low impurity content and suitable for direct recycling
 6.) ²⁴¹Am content determined by gamma spectrometry or alpha spectrometry
 7.) Lower uncertainties are achievable for materials containing low burn up Pu

6. USE OF ITVS

ITVs are considered to be achievable in routine measurements involved in the determination of the amount of nuclear materials for materials accountancy and safeguards verification purposes. They are intended to be used as a reference by plant operators, State systems and international safeguards organizations. They should, however, not be normally used in place of values based on actual measurements in estimating the statistical significance of operator-inspector differences or MUF. Analytical laboratories can find it useful to determine experimentally the actual uncertainties of their measurements, and to compare them with the corresponding values, which can be derived from the ITVs 2000.

Safeguards authorities regularly compare the performance values with the current ITVs. They will examine with the relevant authorities and laboratories means of improving the performance, in cases where the performance values are significantly higher than the ITVs, and too high to allow the IAEA to meet its detection goals. When reliable performance values are not available, ITVs may be used instead to calculate sampling plans, to set reject limits and to calculate estimates of the combined uncertainties of inventories, throughputs, and material unaccounted for (MUF).

Such applications of the ITVs require having a good insight of the measurement and verification systems. It is in particular important to recognize that, because of practical constraints, some measurement steps may be common to the operator and the inspector. It should also not be forgotten that the operator-inspector differences can carry errors which are not related to measurement uncertainties.

7. FUTURE DEVELOPMENTS

It is intended to keep updating the ITV tables regularly in order to incorporate the latest relevant information. The following activities will be especially important for this purpose:

- Growing emphasis is being placed on reassessing the uncertainties of chemical measurements according to the ISO, NIST and EURACHEM guides. This should be done systematically for the methods in current use. It should become a part of the process of qualification of new measurement methods and instrumentation.
- The inspectorates will continue to update actual performance evaluations.
- It is important that interlaboratory measurement evaluation programmes continue to be conducted, particularly in the area of Pu measurements. Operator and inspector laboratories should participate in such programmes. Their results should be published as it was done in the past.
- Models more specific to the NDA measurement processes are being reviewed by the ESARDA/NDA Working Group to monitor and assess the sources of major uncertainties in actual inspectors' measurements. This will hopefully involve uncertainty assessments in line with the above guides as well as periodical estimates of actual Performance Values and the development of interlaboratory measurement evaluation programmes for NDA.
- Results of experimental qualifications of recommended sampling procedures should be made available to the inspectorates to substantiate and expand ITVs for the uncertainty components in sampling procedures.
- The IAEA will also follow with the greatest interest developments in bulk measurements and elemental assays of spent fuel solutions and their impact on the accuracy of the accountability of large throughputs and inventories of nuclear materials at large plants now coming under safeguards.

The IAEA will continue its cooperation on the above topics with Euratom, with State authorities and with the expert groups, which were involved in the review of the ITVs 2000. The next revision of the ITVs will also be another opportunity to seek further contributions from more countries and organizations.

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