Nuclear Reference Materials for IAEA Safeguards

CETAMA 50th Anniversary

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Most countries participate in international initiatives designed to limit the proliferation of nuclear weapons.

The Nuclear Non-Proliferation Treaty (NPT) has been a success.

The IAEA is responsible for the verification aspect of the NPT.

Detection of undeclared nuclear material or activity is a relatively new role for the IAEA.
Safeguards - How is it done?

- The Nuclear Fuel Cycle is the focus of attention.
- The IAEA undertakes regular inspections of civil bulk handling facilities.
- Audit the quantity of material within, and the movement of materials through, the facilities.

IAEA
IAEA Inspections

• IAEA inspectors must independently verify nuclear material inventories using…
  • Containment and surveillance,
  • Counting and measurement of items,
  • Sample analysis
Verification by Sample Analysis

- Verification of declared materials by nuclear material analysis
- Verification of absence of undeclared activity by environmental swipe sample analysis, or forensic analysis of nuclear material
Correctness: Nuclear Material Sample Analysis

- Actinides (mainly U and Pu) from nuclear material samples of all varieties
- Precision and accuracy of analytical results is driven by a “fit-for-intended use” philosophy
- Nuclear material accountancy requires a “state-of-the-practice” level of analytical performance
- Sampling and measurement requirements for both facility operator and safeguards laboratories are guided by an International Target Values document
Completeness: Environmental Swipe Sample Analysis

• High U, Pu instrument sensitivity is needed to detect small releases
• High selectivity is needed, enhanced by high precision and accuracy
• Bulk analysis by ashing and dissolving the whole swipe sample
• Particle analysis involves removal from swipe, location and analysis
Enhanced Particle Analysis Capability

2011: New Clean Lab Extension & LG-SIMS
New Nuclear Material Laboratory

- A new laboratory is planned to replace the 35 year old SAL
- Design is now 30% complete
- Approximately 2x the current lab area
- Designed for optimal workflow
- Commission: 2014
Certified Reference Materials

• Certified reference materials are critical to the success of safeguards
• Chemistry process control, instrument calibration and establishing detection limits, measurement quality control
• Nuclear CRMs present special challenges to users and producers
CETAMA CRMs at the IAEA

- CETAMOX 0
  - 15:1 U:Pu MOX pellets for calibration of composition measurements and quality control
- MP2
  - Pu assay CRM (~98 atom% Pu-239) used for quality control and mixed U-Pu dried spikes
- Serie “Champignons”
  - $\text{U}_3\text{O}_8$ powders (NU) with impurities certified at various concentrations
Example: Uranium Concentration

Percent Difference from Certificate
U Concentration
(EC-110)

Target Value (ITV)

Lab Uncertainty (GUM)

Certificate Uncertainty

EC-110
2007 = 151
2008 = 150
2009 = 121

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Example: Pu Isotopics

Percent Difference From Certificate
(CRM 137)

Certificate Uncertainty (& ITV)

Lab Uncertainty

Number of items
2005 = 152
2006 = 117
2007 = 105
2008 = 64
2009 = 70

240-Pu / 239-Pu

242-Pu / 239-Pu
New Directions for SG- Nuclear Forensics

- Nuclear material samples contain much more information than what SG inspectors have traditionally requested.
- Supplementary analytical interrogation of NM accountancy samples is being applied to answer SG relevant questions.
- More non-accountancy NM samples are being submitted to for analysis.
- RM Producers are feeling these changes, too.
Impurities in Uranium Samples

- Trace levels of metallic elements in nuclear U samples may be used for source attribution, facility characterization, etc.
- ICP-MS is the favoured analytical technique
- Clean lab like conditions needed to mitigate cross contamination
- New reference materials and round robins are needed
Elements of interest; concentrations are certified in available CRMs

Elements of interest; concentrations are not certified in available CRMs

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Age Determination of HEU and Pu

- HEU and LEU CRMs are needed with certified $^{230}$Th/$^{234}$U ratios ranging from ca. $10^{-6}$ to ca. $10^{-4}$
- Plutonium CRMs are needed with certified $^{241}$Am/$^{241}$Pu ratios ranging from ca. 0.1 - 5
Collaborations with CETAMA

- Production of a new impurities-in-uranium matrix CRM for round robin testing. IAEA expressed the need at a 2009 ESARDA WGDA meeting. Samples are distributed and under measurement in nearly 20 labs.
- EQRAIN U and Pu round robin testing
- ESARDA Working Group on Techniques and Standards for Destructive Analysis (WGDA)
CRM Needs for Safeguards

- LEU (> 5% enriched), HEU CRMs with uncertainties equivalent to presently available CRMs like IRMM-18x Series
- Recertification of some existing Pu CRMs is needed
- Pu isotope CRMs with various Pu-239/Pu-240 ratios
- Radiochronometry CRMs with certified ages (e.g., Th-230/U-234 and Pu-241/Am-241)
- Trace impurity natural U oxide CRMs for trace elements different to existing CRMs (NBL 123 & 124, CETAMA Champignons).
- Np assay plus Np-236/Np-237 CRM, and Am assay plus Am-241/Am-243 CRM for mass spectrometry
Interlaboratory Comparisons

• The CETAMA EQRAIN U and Pu interlaboratory control programs are important for external quality control

• Trace Impurities in Uranium Matrix program is an important development
Conclusions

• The nuclear safeguards measurement community depends on certified reference materials for verifying the correctness and completeness of State inventories.
• Improvements in mass spectrometry require re-certification of older CRMs (esp. Pu).
• The growing emphasis on nuclear forensic measurements will require development of new CRMs.
Conclusions

- Interlaboratory comparison programs are extremely important and should be continued, and perhaps expanded to include the nuclear forensic measurement area.
- The IAEA works closely with the French Support Programme to the IAEA to facilitate CRM needs now and in the future.
Congratulations CETAMA!