Practical U-Enrichment Measurements

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Non-Destructive U-Enrichment Measurements for Safeguards Purposes in Brazil

- International & Regional Inspectorate: IAEA and ABACC
- Typical Items
  - UF6 Cylinders
  - UO2, U3O8 Powder Drums
- Typical Measurement Systems and Codes
  - HRGS: High Resolution Gamma Spectrometry (HPGe) + Inspector2000 MCA with IMCA or MGAU)
  - ECGS: Electrically Cooled Germanium System (HPGe + Enrichment Meter Code)

Non-Destructive U-Enrichment Measurements for Domestic NMC&A

- National Inspectorate: CNEN
- Typical Items
  - UF6 Cylinders
  - UO2, U3O8 Powder Drums
  - Samples: Fuel Pellets, UO2 and U3O8 Powders
- Typical Measurement Systems and Codes
  - HRGS: High Resolution Gamma Spectrometry (HPGe) + DSA1000 MCA with MGAU)
  - LRGS: Low Resolution Gamma Spectrometry (NaI) + MMCA-166 with NaIGEM)

UF6 Cylinder Measurements

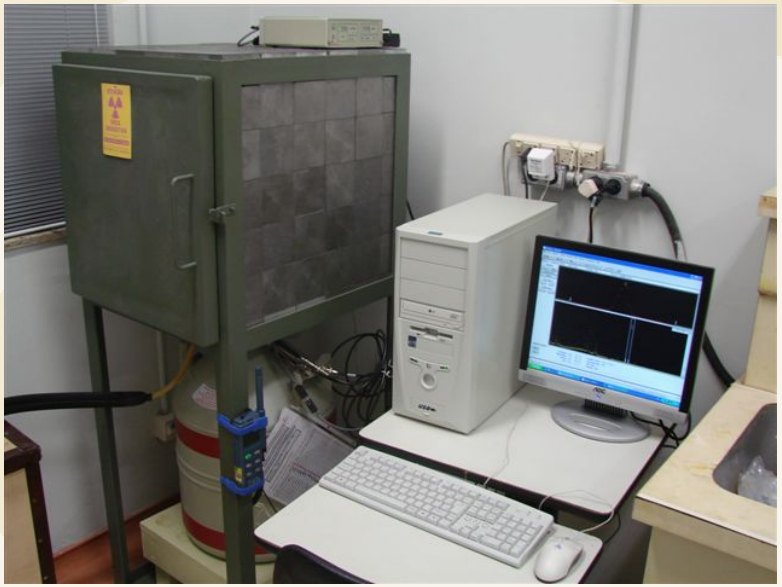
- About 40 low enriched (1.9 – 4.3% U235) UF6 cylinders per year are received (from URENCO) and processed at the Fuel Fabrication Plant
- A few additional cylinders produced at the Enrichment Plant (under commissioning) located in the same site
- 100% of the cylinders are measured for U-enrichment determination as part of the quality control prior to processing
- The NDA technique used is the low-resolution gamma-ray spectrometry (NaI detector) and the NaIGEM (v.152a) code
- Measurement conditions:
  - Wall thickness measurement using a traditional thickness gage. Cleaning of the external surface within the area viewed by the detector
  - U-Enrichment calibration using SRM-969 and an additional absorber (same material, same thickness)
  - 3 x 10 min replicate measurements per cylinder, at different positions

Performance Values
(2 – 5% U235)

Uncertainty Component	Probability Distribution	Enrichment Uncertainty (%rel.)	Uncertainty Budget (%)
(1) CRM Certified Value	TYPE B - Normal	0.036	0.03
(2) Additional Calibration Absorber	TYPE A - Normal	0.056	0.06
(3) Calibration Repeatability	TYPE A – Normal	0.28	1.62
(4) Sample Measurement Repeatability	TYPE A - Normal	2.1	91.12
(5) Resolution of the Digital Thickness Gauge (0.1mm)	TYPE B - Rectangular	0.45	4.18
(6) Wall Thickness Determination in 30B Cylinders	TYPE B - Normal	0.4	3.31
COMBINED STANDARD UNCERTAINTY		**2.20**	100%

Fuel Pellets and Powder Measurements

- Samples of Fuel pellets and UO2 powders are collected at the Fuel Fabrication Plant
- U-enrichment measurements are conducted in the laboratory using the MGAU code in the “Standard Mode”
  - Low BG
  - Resolution (~510eV @ 122KeV)
  - Multiple replicates
  - Secular equilibrium is required
- U3)8 Powder CRM´s were used for long term uncertainty estimation
- U-enrichment results are obtained within 0.5% rel.std. uncertainty (average of multiple replicates)
- The technique allows for verification of declared U-enrichment values



Conclusions

- Some elements that can significantly improve U-enrichment by Gamma-spectrometry
  - Use of Advanced NDA codes (MGA, MGAU, PC-FRAM, NaIGEM etc)
  - Procedures
  - Training, in particular for measurements in the field

- U-enrichment by Gamma-spec in a laboratory environment can replace DA under specific conditions
  - Sample quantity
  - Sample Homogeneity
  - Sample geometry
  - High quality detectors
  - Advanced codes

Conclusions

- ITV´s for U-enrichment by Gamma-spec (Table 5b) are uncertainty estimates under “IAEA inspection conditions”
  - Operator´s conditions are usually different (may be much better)

- Are these notes (Table 5b) really valid??

4/ Spectrum analysis: infinite thickness method (enrichment meter principle).

5/ Similar uncertainties should be achievable for peak fitting based spectrum analysis methods. (NOTE FOR LOW RESOLUTION GAMMA-SPEC)

8/ Similar uncertainties are expected for intrinsic calibration based spectrum analysis methods (e.g., MGAU). (NOTE FOR HIGH RESOLUTION GAMMA-SPEC)

Thank you for your Attention!

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