The processes for fissile material flux management: theory vs. practice
Outline

- Operational Experience Feedback
- Scope and objectives of the presentation
- Bel V approach
- Bibliographical and on-site study
- Sampling and analysis
- Results and discussion
- Conclusions
Operational Experience Feedback (OEF)

- Process is part of the Quality System (ISO 9001:2008)
- Internal – External OEF (different input, same output)
- Identification of events/incidents relevant to nuclear safety/radiation protection by a multi-disciplinary team
  - Insertion in a database (with all the relevant information)
  - Periodic meetings with inspectors to discuss the inserted events and to select some of them for further analysis
  - In-depth analysis by experts
  - Communication of the results to inspectors
  - Communication to the licensee

- Further use of database
Scope and objectives of the presentation

- Bel V reacted notably to OEF from ATPu (CEA):
  - 2006: Accumulation of MOX in a glove box - loading of twice the expected FM amount
  - 2009: Accumulation of Pu due to underestimation of FM retention
- Emphasis on fissile material flux management
- Criticality studies will not be discussed but were performed by the licensee and analyzed by Bel V
- Focus on liquid solutions rather than on solid state fissile material
- Evaluation of uncertainties is still on-going
- Sampling and analyzing methods used by the licensee were studied in-depth by Bel V
Bel V approach

8 steps

- Study of the licensee’s official accountability determination process
- In-depth study of the licensee's “production” processes
- Bibliographical studies of licensee's processes
- Localization of potential accumulation places in the installation
- Sampling and analyses by the licensee
- Comparison of analyses results and official accountability
- Potentially suggest processes modification
- In future, potential correction of official FM accountability
Bibliographical and on-site study

Steps 1 to 4

- Study and comparison of:
  - FM official accountability
  - Processes involving FM and carried out on site
  - History of installation and incident reports (e.g. hazardous mixes)
  - Data found in literature/papers (yields, SAR,...)

- Identification of potential parts of the processes where FM accumulation was suspected

- Sampling and analyses of parts of equipments or processes was requested by Bel V in suspicious places
Sampling and analysis
(1/2)

Step 5

● Several analyzes techniques were used by licensee:

  – HPGe/HPGe with ISOCS
    • Quantification of U-235 in liquid solution or in sediments at the bottom of tanks
  – $\alpha$-emitters spectrometry
    • Notably to determine Pu-239 activity in liquid solutions
  – Liquid scintillation counting ($\beta$-emitters)
    • Notably to determine Pu-241 activity in liquid solutions
  – ICP-MS
    • Quantification of U in liquid solution or solid precipitate
  – Classical chemical analyses
    • pH, $\text{Cl}^{-}$ content, weighing of precipitates,…
Advantages and drawbacks of used analysis techniques:

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<th>Accumulation place localization</th>
<th>Quantification of accumulated fissile material</th>
<th>Geometrical problem</th>
<th>Sampling treatment</th>
<th>Accuracy of the analysis</th>
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Results and discussion (1/2)

Two major findings:

1. Underestimation of a production process yield

- Official FM accountability relies on a production yield defined as such:
  - 95 % of U-235 stays in the solid state
  - 5 % of U-235 ends up in liquid wastes

- After sampling and analyzing, determined production yield:
  - 97-98 % of U-235 stays in the solid state
  - 2-3 % of U-235 ends up in liquid wastes

- Increase of a couple of kg of U-235 in the on-site storage
- Consequent decrease of U-235 content in liquid wastes
Results and discussion (2/2)

2. Hazardous mix of acidic and basic waste solutions

- Mix of liquid wastes coming from different licensees:
  - Different chemical characteristics (U/Pu, Cl⁻, F⁻, pH, ...)

- Mix of liquid wastes coming from the same licensee:
  - Different chemical characteristics especially pH

- Mixes led to precipitate formation that deposit at the bottom of waste tanks

- Precipitate and solution were analyzed:
  - No U-235 in solid state
  - Pu-239 and Pu-241 in solid state

On-going quantification
Conclusions

- No major problems detected – no immediate actions needed
- Accumulation rate of FM was found higher than expected in some stages of processes
- Localization of places where fissile material flux management had an important long-term impact due to:
  - Unexpected chemical side-reactions
  - Alteration of FM molecular form
  - Small repeated mistakes
  - Very slow kinetic reaction
- Impact of official FM accountability of one licensee on the other’s
- Person in charge of FM accountability should have in-depth knowledge of all processes involving FM