



Idaho National Laboratory

Material Control & Accountancy

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Accounting – the Goal

- **Measure the Goesingas**
- **Measure the Goesoutas**
- **Verify that the difference is zero**

Accounting – Reality

- **Devise a system of tracking, measuring, and accounting for nuclear material to deter or detect theft or loss**
- **The IAEA accounting goal is to devise a system whereby the State's accountancy program and its results can be *verified***

Accounting – Verification

- **Nuclear material accountancy is the principle means employed by the IAEA to independently verify the correctness of the accounting information provided by the State**
- **The State (i.e. facility operator, regulators, etc.) must have an accounting system of their own**

Accountable Materials

- The materials of interest are those which can be used to produce a nuclear weapon

- Fissile

- ^{235}U , ^{239}Pu , ^{241}Pu , ^{233}U

All Pu isotopes are
Considered together
by the IAEA

- Fissionable

- ^{238}U , ^{240}Pu , ^{242}Pu

- Fertile

- ^{238}U , ^{232}Th

Uranium is typically categorized as
Low Enriched (LEU) or
High Enriched (HEU)

Two Accounting Regimes

- **Item – Intact Whole Items**
 - **Reactor fuel elements**
 - **Sealed cans of material**
- **Bulk – Material in “loose” form**
 - **Dissolved Pu concentration in a PUREX plant**
 - **Hold-up trapped in process piping**
 - **400,000 pebbles in a PBMR core**

Accounting System

- **The accounting system will include**
 - **Accounting practice using Generally Accepted Accounting Principles to track movement and inventory of materials**
 - **Key Measurement Points to determine material flow and inventory**
 - **Material Balance Areas to enable material accounting and measurement**
 - **Periodic inventories to determine material quantities**
 - **A measurement program utilizing either (or both) non-destructive and destructive assay techniques**

GAAP

- **Generally Accepted Accounting Principles (GAAP)**
 - **Standard accounting guidelines, rules, conventions etc.**
 - **In other words – Good Practice**

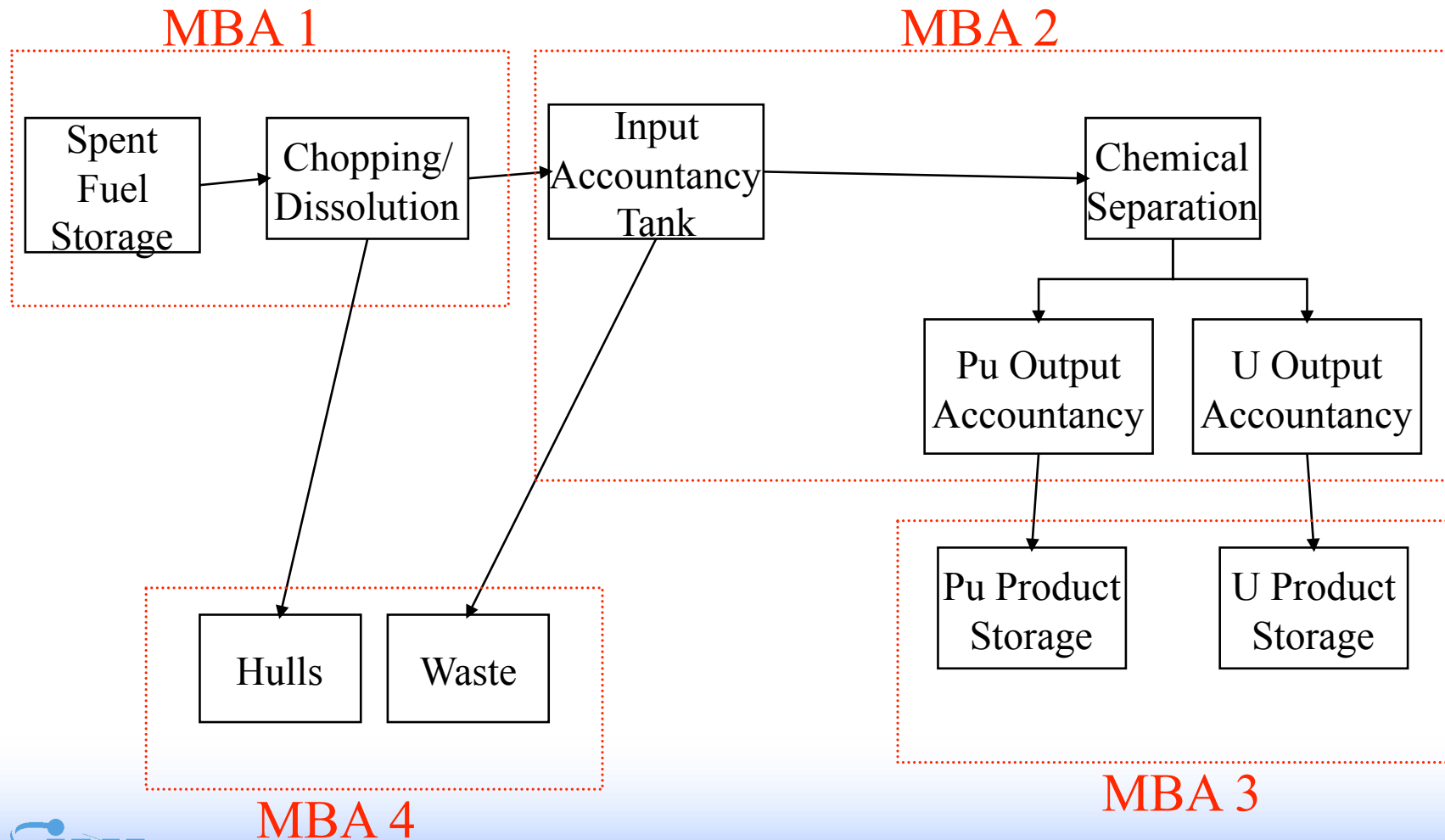
KMP

- **Key Measurement Points (KMP) are locations in the facility where the material can be measured**
 - **Determine/verify material flow**
 - **Perform inventory measurement**
 - **Input/Output points**
 - **Storage areas**

MBA

- **Material Balance Areas (MBA) are defined areas of the facility to allow material accounting**
 - **The material inventory in the MBA can be determined**
 - **Transfers into or out of the MBA can be tracked and accounted for**
 - **KMPs are often MBA boundaries**
 - **Size of the MBA (or, rather, the amount of material within it) should reflect the ability to measure the material inventory**

MBA Example – Processing Facility



Material Balance Period

- **The time period between inventory measurements is the material balance period**
 - **Corresponds to either**
 - **Regulated or allowed time period**
 - **Time period required to meet timeliness goals**

Book vs. Physical Inventory

- **Book inventory is the value in your records**
 - **Plus transfers in**
 - **Minus transfers out**
 - **Summed over the balance period**
- **Physical Inventory is what is actually present**
 - **Quantities in containers**
 - **Hold-up**
 - **Losses to waste**
- **The physical inventory becomes the book inventory for the next balance period**

ID and MUF

- The Inventory Difference (ID – U.S. DOE) or Material Unaccounted For (MUF – IAEA) is the difference between the expected material quantity and the measured amount
 - May be due to measurement uncertainty
 - Might be due to theft, loss, or diversion



The goal of material accountancy is to deter or detect this possibility!

Measurement Uncertainty

- All measurements have uncertainty
 - Random Errors
 - Systemic Errors
- Measurement uncertainty must be propagated through the accounting calculations

The uncertainty always grows
larger as is it propagated!

Confidence Levels

- A measured value \pm its uncertainty (usually expressed as “sigma,” or σ) represents a confidence level
 - You are “confident” that the exact value lies within the range described
- $\pm 1\sigma$ gives 68% confidence
- $\pm 2\sigma$ gives 95% confidence
- $\pm 3\sigma$ gives 99% confidence

- Many safeguards conclusions require 99% confidence

Sampling

- **It is often unrealistic (cost and time) to measure every item**
 - **A sampling plan can be devised to attain the required confidence level**
 - **Representative samples are harder to produce than you would think**
 - **Items are often stratified to improve representativeness**
 - **Usually entails stirring and mixing to homogenize material (especially powders and solution tanks)**

Shipper/Receiver Difference

- Shipper has a value for items they ship
- Receiver measures items upon receipt
- They never match (remember measurement uncertainty)

- The shipper/receiver difference has to be reconciled
- Just like inventory differences, the shipper/receiver difference must be resolved (with appropriate confidence)

Non-Destructive Assay (NDA)

- **NDA is the primary workhorse of accountancy for sealed items**
 - **Calorimetric measurements for plutonium**
 - **Coincidence neutron counting for plutonium**
 - **Active Differential Die-Away Techniques for Uranium**
 - **Peak Ratio Techniques for Uranium Enrichment**
- **Perform measurement without destroying material**
- **Can be active or passive**

Destructive Assay (DA)

- **Small amount of material is destroyed to perform measurement**
 - **Mass spectroscopy**
 - **Alpha Spectroscopy**
 - **Chemical Analysis**
- **The primary workhorse of bulk-material handling facilities such as reprocessing facilities**
- **Often can require sampling ports, which should be designed in advance in facilities**

NDA vs. DA

NDA

Faster

Cheaper

No material destroyed

Performed in situ

Higher uncertainty

DA

Slower

More expensive

Destroys sample

Requires laboratory

Much Lower Uncertainty

International Standards of Accuracy

- **There are International Target Values for given measurement systems, or given process flows**
 - **Based upon what is typically achieved at various facilities**
 - **Based upon what can be expected of instruments in the field**
- **Accountancy system must be able to achieve confidence levels if the measurements are only as good as the International Standards**
 - **Target values have been released by the IAEA**
 - **Almost an order of magnitude behind the state-of-the-art**

Containment and Surveillance

- **C/S is used to augment/complement accountancy**
- **IAEA makes extensive use of**
 - **Cameras**
 - **Seals**
- **Allows some inventory/measurement requirements to be relaxed**
- **Allows declarations of activities to be verified**
- **Allows verification of hard to measure activities**

- **Can require a lot of inspector time to analyze data**

Summary

- **The goal of nuclear material accounting is to deter or detect theft, loss, or diversion of nuclear material**
- **A State must have its own system of accounting**
- **The IAEA independently verifies the State system's declaration**
- **Measurement uncertainty is a major factor in bulk material facilities**
- **Containment and Surveillance are used to complement the accountancy system**