Accountancy and Control of Obligated Nuclear Material in the United States

6.0 Application of equivalence & proportionality to obligated material

Presentation Outline

I. Introduction
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Introduction

- The U.S. is not trying to track atoms.
- There are no little flags on atoms of uranium.
- Uranium is a fungible material – all atoms of uranium are interchangeable
- Within a facility, assignment of obligation is a matter of equivalence , proportionality and operational expediency.

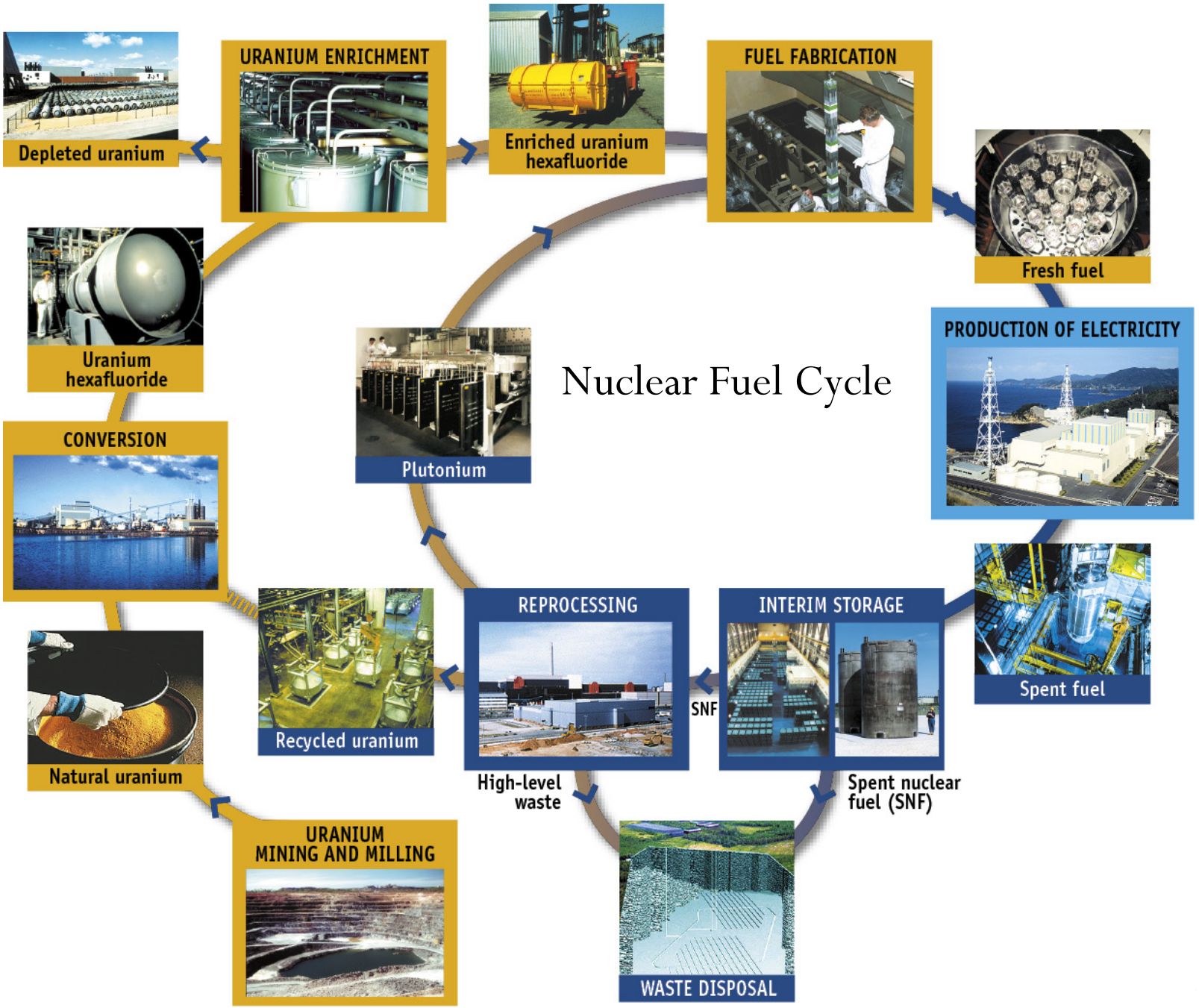
Introduction

- The aim is fair and accurate assignment of obligations to nuclear material as it flows through the U.S. fuel cycle.
- To achieve this aim facilities often have to make proportional assignment of obligations to both material inventories and production and losses within facilities.

Fungibility

- The international nature of nuclear material flows means that uranium from many sources is routinely mixed during processes such as conversion and enrichment.
- Uranium is termed a "fungible" commodity, that is, at these processing stages uranium from any source is identical to uranium from any other—it is not possible physically to differentiate the origin of the uranium.
- There are many places within the nuclear fuel cycle where fungibility is applied.

Nuclear Fuel Cycle



Equivalence (1)

- The equivalence principle provides that where obligated nuclear material loses its separate identity because of process characteristics (e.g. mixing), an equivalent quantity is designated obligated, based on the fact that atoms or molecules of the same substance are indistinguishable, any one atom or molecule being identical to any other of the same substance.

Equivalence (2)

- Equivalent quantities of the products of such nuclear material may be derived by calculation or from operating plant parameters.
- The principle of equivalence does NOT permit substitution by a lower quality material, e.g. enriched uranium CAN NOT be replaced by natural or depleted uranium, unless otherwise jointly agreed.

Equivalence example

- Facility receives 10 fuel assemblies each listed as containing 20% of obligated material?
- Obligations can be reassigned within the group of assemblies so that two assemblies are counted as having 100% of obligated to simplify reporting requirements (provided substitution is strictly like-for-like).

Proportionality principle

- The proportionality principle provides that where obligated material is mixed with other nuclear material, and is processed or irradiated, a proportion of the resulting material will be regarded as obligated corresponding to the same proportion as was obligated initially.
- In the case of enriched uranium, the proportion is based on the mass of the isotope U235 or the isotope U233 or both.

Material flows

- Obligated material must flow in a logical fashion through the fuel cycle.
- Obligated material must be: converted; enriched (if necessary); fabricated into fuel; used in reactors; stored as spent fuel and so on.
- Equivalence CAN NOT be used to assign obligation to a static inventory of material that grows but never progresses through the fuel cycle.

Example 1 – Blending LEU

- Blending of 3% enriched obligated LEU with 4% unobligated LEU (assuming for this example 50% of the material being mixed is obligated).
- Average enrichment of final mix is 3.5%
- Proportion of LEU that is obligated ≈43%

Example 2 –Irradiation

- Nuclear loss (LEU consumed) and nuclear production (plutonium) is apportioned on the basis of element weight.
- Using fuel from example 1:
  - Obligated share of U-235 nuclear loss ≈43%, and
  - Obligated share of Pu production ≈43%

Example 3 – Irradiation

- If reactor core comprises 50% obligated enriched to 3%, and 50% other material enriched to 4%:
  - Obligated share of U-235 nuclear loss ≈43%, and
  - Obligated share of Pu production =50%

Example 4.a – process losses/hold-up

- Obligated material used at a facility with process hold-up amounting to 1% of throughput and process losses amounting to 0.5% of throughput (values measured not inferred).
- If obligated material amounts to 10% of throughput then both the losses and hold-up can be proportionally assigned to obligated (e.g. – if processes losses are 1 MTU obligated then losses recorded against obligation would be 100kg).

Example 4.b – process losses/hold-up

- Facility clean-up for physical inventory taking results in 99% hold-up recovery.
- If reported hold-up reduced obligated inventory by 100kg obligated, then recovery of 99% of hold-up should increase obligated inventory by 99kg.

- Quantities must match reported proportions!

Example 4.c – process losses/hold-up

- Recovery of material that was previously counted as measured discard/process loss.
- Assigned obligated quantities must not exceed assigned share of process loss

Frequently asked questions

- Is it possible to substitute uranium for plutonium in accounts? – No.
- Is it possible to substitute LEU for HEU in accounts? – No.
- Is it possible to substitute NATU or DEPU for EU? – No, unless jointly agreed
- Is it possible to substitute irradiated material for unirradiated material? – No.

Summary

- Equivalence and proportionality are means of recognizing the reality of nuclear processing and the fungibility of uranium.
- Rules are meant to be applied in a common sense fashion to ensure that obligated material is appropriately accounted for as it flows through the nuclear fuel cycle.