



Downblend and Disposition Remote Handled U-233 Material

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Purpose

- ▶ Discuss criticality evaluation of Isotek material
- ▶ Discuss regulatory path for transport approval



Objectives

- ▶ Obtain concurrence for criticality evaluation method
- ▶ Obtain concurrence for the regulatory path to transport approval



History

- ▶ Isotek at ORNL
- ▶ U-233 Repository
 - Material from SRS, ORNL, RFTS, LLNL & LANL



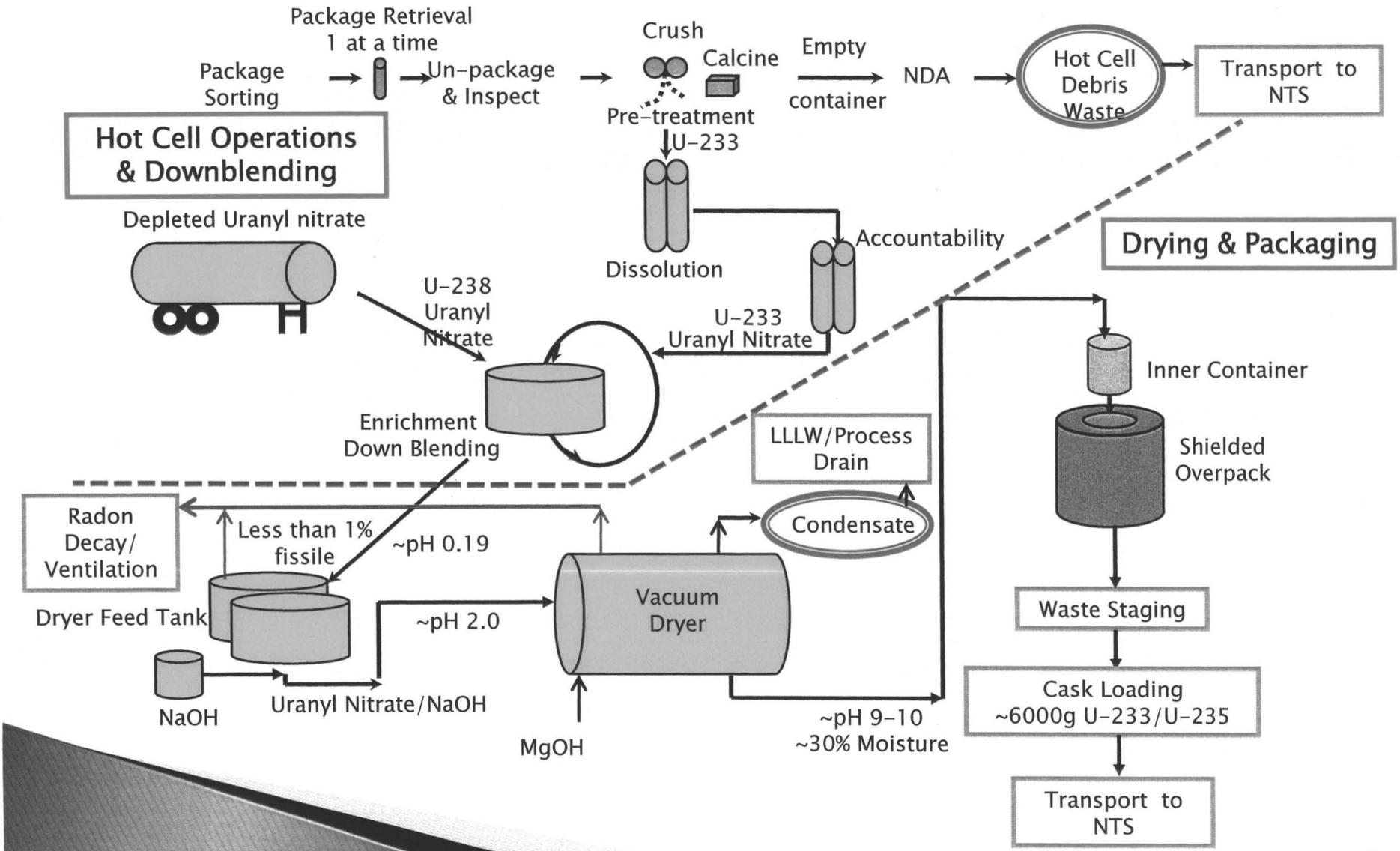
Project Scope

- ▶ Design/Build a Processing Facility to Remove Security and Safeguards Concerns of the U-233 Inventory





Process Overview





Project Goal

- ▶ Downblend the U-233 Inventory to Address the Following Elements:
 - Criticality
 - Attractiveness
 - Security
 - Safeguards
 - NTS Compliant



Waste Characteristics

- ▶ Required Criticality Limits and Isotek Waste Parameters after Downblending:
 - NTS: 300 PE-g/container, 7000g U-235 equivalent/container at .95% enrichment
 - Isotek: 140 PE-g/container, 628g U-235 equivalent/container at .95% enrichment



Waste Characteristics

- ▶ Physical Form/Properties
 - Uranium Salt Monolith
 - No Free Liquids
 - <1200 lbs/Container
 - Transuranics <100 nanocuries/gram
 - Subcritical in an Infinite Array
 - Compliant with 40CFR, 10CFR and 49CFR



Project Schedule

- ▶ Project is at the 60% design phase
- ▶ Processing and Shipments to Begin in Early 2013



Criticality

- ▶ Material Specifications
- ▶ Equivalence Basis
- ▶ Analysis Methodology
- ▶ Preliminary Results



Payload Material

- ▶ Isotopically downblended material is designed to be inherently subcritical assuming:
 - Water moderation
 - No presence of Be, D₂O, or C
- ▶ Isotek payload fissile amount is governed by a process formula.
 - Formula gives DU required to dilute an enriched uranium stream to inherently subcritical limits, regardless of ²³³U/²³⁵U ratio.
- ▶ Isotek specification is similar to, but does not match § 71.15 fissile-exempted material.



Fissile Material Specification

- ▶ For mixtures of ^{233}U and ^{235}U , the amount of DU (with 0.2 wt % ^{235}U) in grams (g) required to ensure criticality control by isotopic dilution in a water-moderated system is the following:

$$g_{\text{DU}} = 188 \cdot g_{\text{ }^{233}\text{U}} + \left(\frac{E - 1}{0.8} \right) \cdot g_{\text{enriched U}}$$

where

- ▶ DU = g of DU (0.2 wt % ^{235}U)
- ▶ E = the wt % of ^{235}U
- ▶ g of enriched uranium = total U - ^{233}U



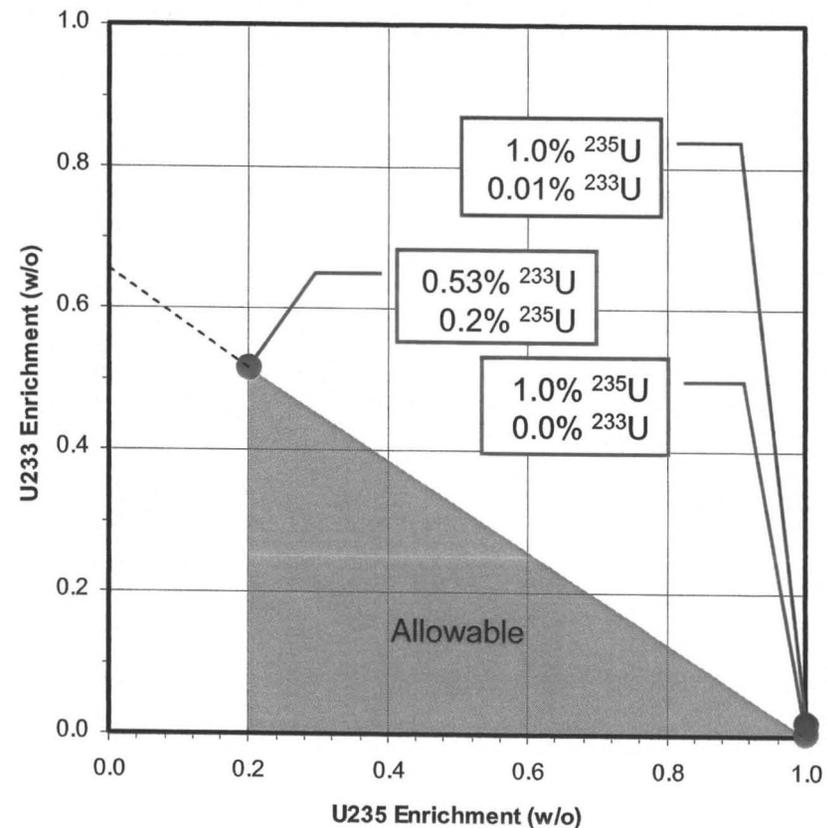
71.15 Fissile Material Exemption

§ 71.15 Exemption from classification as fissile material.

- ▶ Fissile material meeting the requirements of at least one of the paragraphs (a) through (f) of this section are exempt from classification as fissile material and from the fissile material package standards of §§ 71.55 and 71.59, but are subject to all other requirements of this part, except as noted.
 - (d) Uranium enriched in uranium-235 to a maximum of 1 percent by weight, and with total plutonium and uranium-233 content of up to 1 percent of the mass of uranium-235, provided that the mass of any beryllium, graphite, and hydrogenous material enriched in deuterium constitutes less than 5 percent of the uranium mass.

Fissile Limit Comparison

- ▶ ORNL/TM-13524
 - 0.66% ^{233}U = 1.0% ^{235}U
- ▶ § 71.15 Fissile Limits
 - 1.0% ^{235}U with 0.01% ^{233}U
- ▶ Isotek Fissile Limits
 - Variable 233/235 scale
 - 1.0% ^{235}U with 0.0% ^{233}U
 - 0.53% ^{233}U with 0.2% ^{235}U
 - Assumes DU is 0.2% ^{235}U





Equivalence Basis

- ▶ We propose that the basis for the criticality evaluation be a comparison between the §71.15 (d) fissile exempted material and the Isotek material.
- ▶ If we can demonstrate that k_{eff} over the full range of allowable Isotek material, is bounded by k_{eff} for the exempted material, then the Isotek material is acceptable for transport.



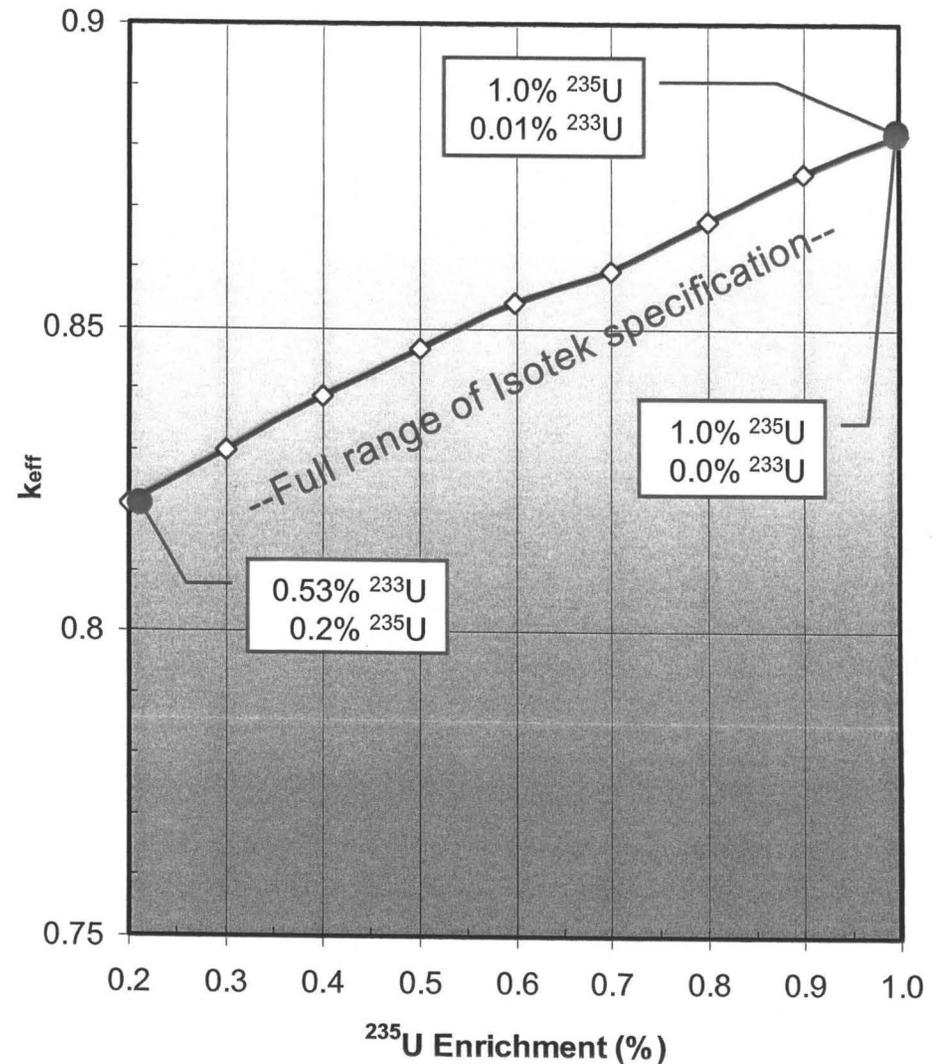
Methodology

- ▶ Model 1000kgU, optimally moderated spheres with full water reflection.
 - k_{eff} vs. H/X for full range of formula
 - k_{eff} vs. H/X for exempted material
- ▶ MCNP5 with .66c cross sections (ENDF66c, based on the ENDF/B-VI release 6).
- ▶ 250,000 neutron histories per case with approximately 0.1% relative errors.



Preliminary Results

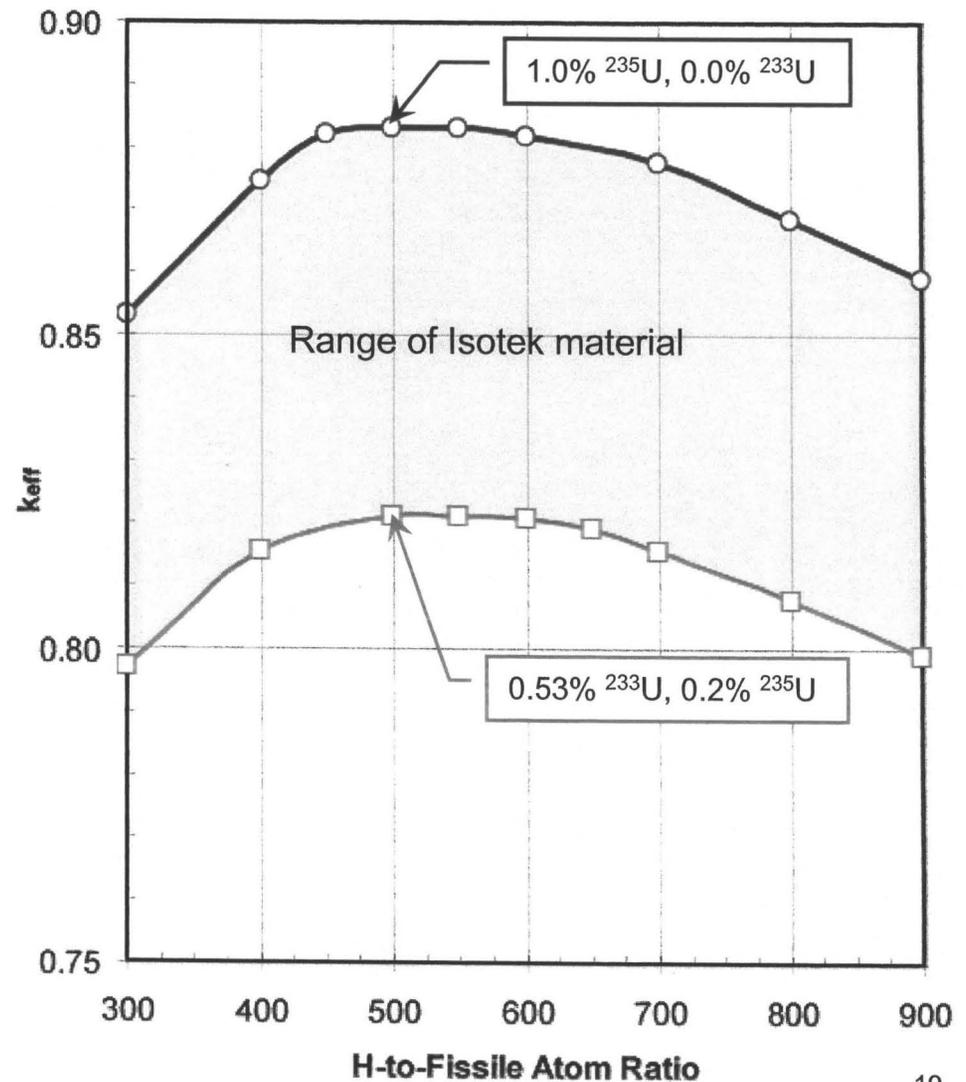
- ▶ §71.15 (d) fissile exempted material
- ▶ Isotek material
- ▶ Results show that Isotek material is equal or less reactive than the exempted material over the full range of $^{233}\text{U}/^{235}\text{U}$ ratio.





Preliminary Results

- ▶ H/X studies show that:
 - Curves are flat near the peaks.
 - Peak H/X ratio does not change with enrichment.
- ▶ No changes to conclusion that Isotek material has equal or lower reactivity than §71.15 (d) fissile exempted material





Criticality Conclusions

- ▶ Isotek material is designed to be inherently critically safe.
- ▶ Is like § 71.15 exempted material, but does not match exactly.
- ▶ We propose to demonstrate criticality safety by comparing Isotek material to the exempted material.
- ▶ Preliminary criticality calculations show that the Isotek material is equally, or less, reactive than the exempted material.



Regulatory Path

- **Preferred Path:**
 - Request that Isotek material be exempted from classification as fissile material and from the fissile material package standards of 10 CFR 71.55 and 71.59 as authorized by 10 CFR 71.12



Submittal

▶ Preferred Path

- Request for exemption per 10 CFR 71.12
- Description of Isotek material
- Demonstration that Isotek material is less reactive than material exempted under 10 CFR 71.15



Regulatory Path

▶ **Alternative Path**

- Request revision to CoC of the 10-160B package
- Submit stand-alone appendix to the SAR for the Isotek material
- Appendix formatted per Reg Guide 7.9
- Show the base SAR bounds the structural, thermal, containment, and shielding issues
- Show criticality requirements are satisfied



Submittal

▶ **Alternative Path**

- Revised 10-160B SAR including Isotek Appendix