ANS Winter Meeting & Expo

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Joining Forces to Advance Nuclear

Concurrent Uranium Overmass and Hydraulic Fluid Leak

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Y-12 Nuclear Criticality Safety

Y-12 National Security Complex

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Overview

- Introduction to the Reduction Process
- Reduction Criticality Safety Evaluation
- Hydraulic Leak Event
- Clean-out of the Sand Separator
- Causes
- Physical and Administrative Changes

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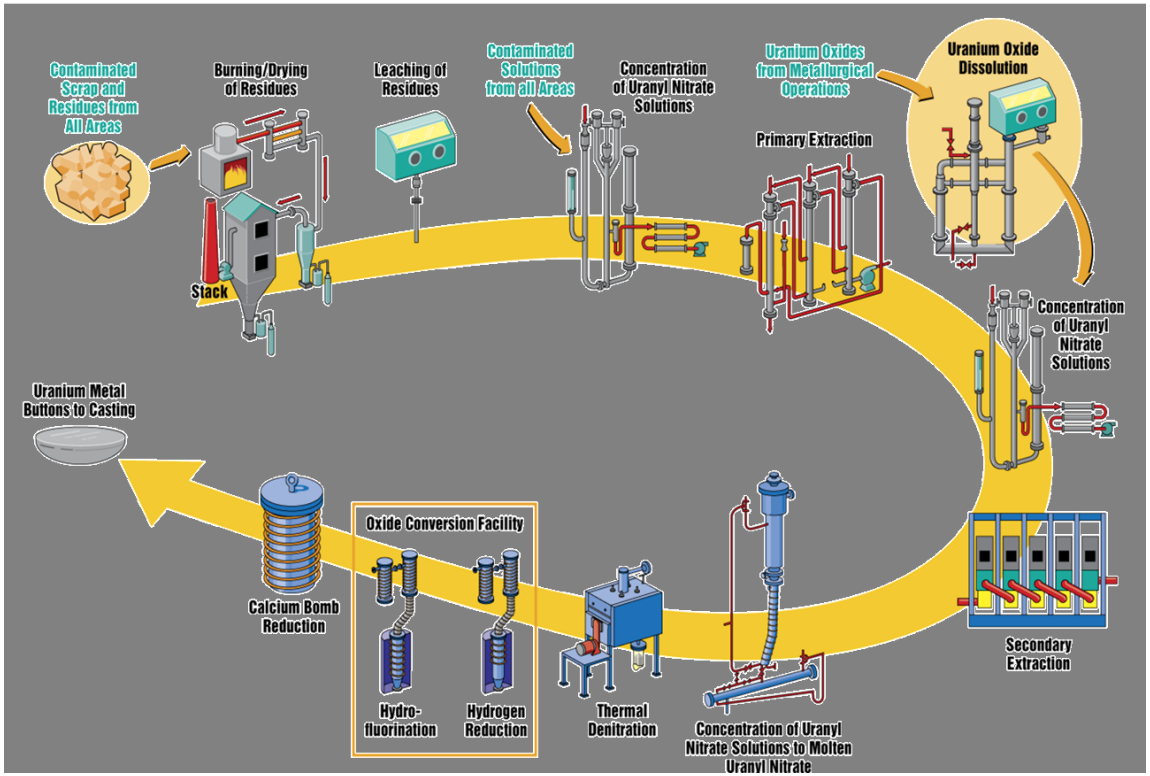
Introduction to the Reduction Process

- Process involves the reduction of UF_4 to a relatively pure uranium metal button and CaF_2 slag



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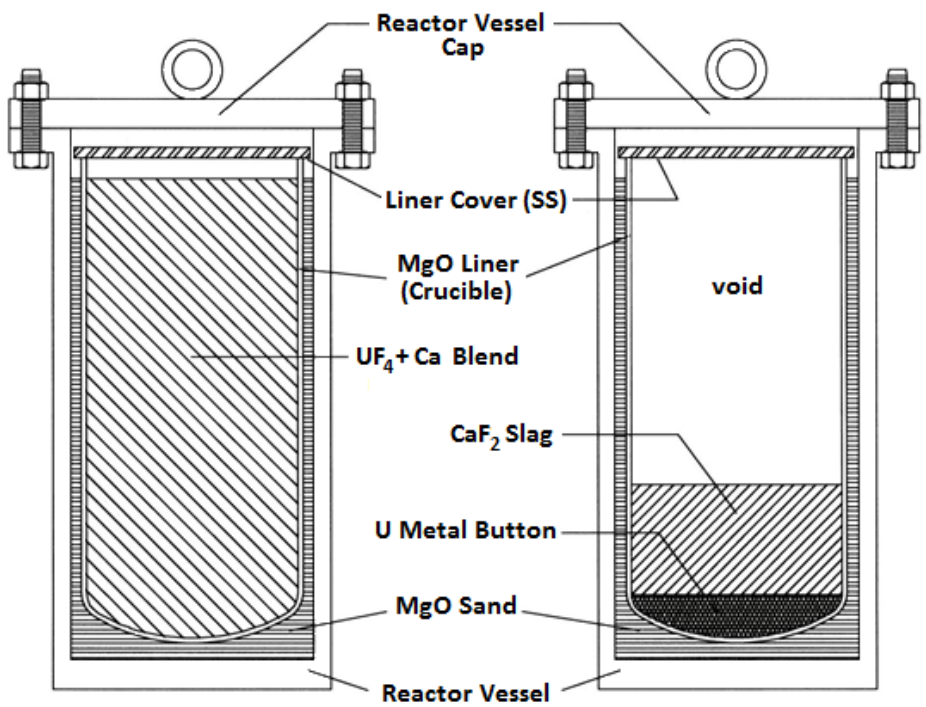
Introduction to the Reduction Process

- Reduction takes place in a stainless steel reactor vessel with a MgO liner and sand



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Introduction to the Reduction Process

- Vessel is heated in an induction furnace and cooled

Introduction to the Reduction Process

- The vessel is transported to a Knockout Glovebox

Introduction to the Reduction Process

- Vessel contents are “knocked-out” using a hydraulically operated jolter

Introduction to the Reduction Process

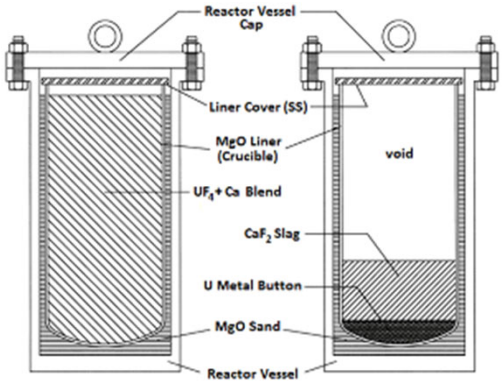
- Liner, uranium-bearing slag, and uranium-contaminated sand are processed separately
  - Sand is fed through a chute to a vibrating sieve-like sand separator
  - Slag and the MgO liner are sent down a separate 6” diameter chute directly to accumulation can

Introduction to the Reduction Process

- The sand separator has 3 levels that separates large particles, sand, and fines

Reduction Criticality Safety Evaluation (CSE)

- Abnormal condition analysis evaluated liquid intrusion into the Knockout Glovebox
  - Subcriticality only demonstrated for a single, intact uranium metal button with full water reflection
  - No liquid drainage system required
- Assumed minimal amounts of uranium in the MgO sand



Reduction Criticality Safety Evaluation (CSE)

- No mass limit required for the sand separator
- Uranium was expected in the slag, liner, and sand
  - Required a dimensionally controlled accumulation can
  - Assumed can would be changed-out frequently

Hydraulic Leak Event

- Hydraulic leaks on the jolter occurred in April and May of 2017

Clean-out of Sand Separator System

- Disassembled components and collected material in a nearby hood

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Clean-out of the Sand Separator

- Total mass collected was over 30 kg
  - U-235 mass was ~3.5 kg

Section	Net Mass	U-235 Mass
Accumulation Can	~10000 g	1226 g U-235
Bottom of Sand Separator	9098 g	864 g U-235
Middle of Sand Separator	640 g	23 g U-235
Top of Sand Separator	33 g	33 g U-235
6 in Chute	2861 g	291 g U-235
3 in Chute	9395 g	1149 g U-235

Cause #1

- Operating procedure did not have requirements for emptying the accumulation can

Cause #2

- Method for collecting slag changed from collecting in the accumulation can to collecting in a can on the glovebox floor

Cause #3

- Reduction process drifted from producing intact buttons to occasionally producing low quality or multi-piece buttons

Cause #4

- No NCS analysis or controls on mass or moderation of material collected in the sand separator

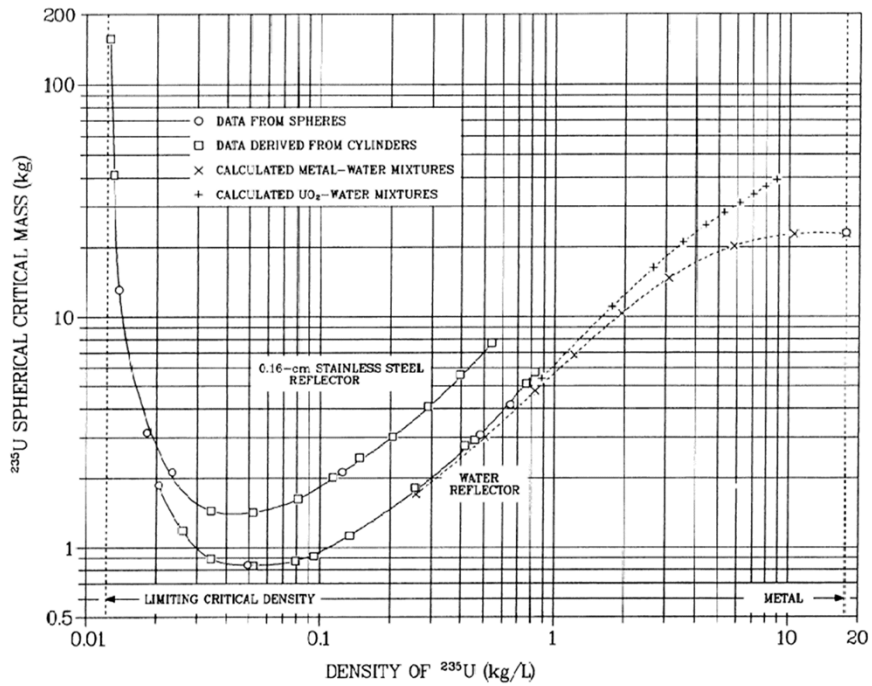

Fig. 10. Critical masses of homogeneous water-moderated U(93.2) spheres. Solution data appear unless indicated otherwise.

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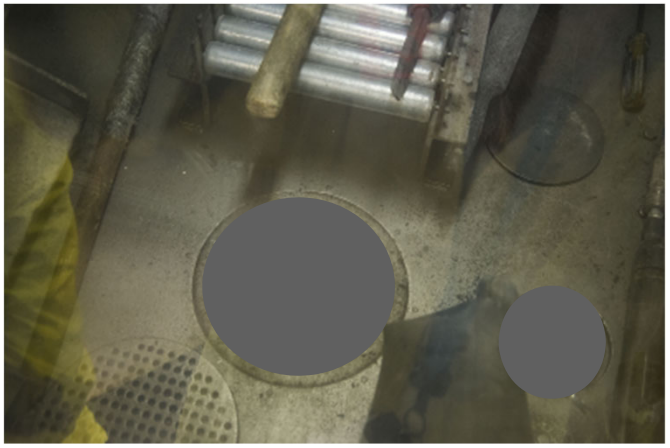
Physical Design Changes

- Installed new, more robust hydraulic lines
- Installed plugs for both chutes
- Limited the hydraulic fluid reservoir
- Installed a glovebox drainage system



Administrative Changes

- 700 g U limit established for the accumulation can, sand separator, 3” diameter chute, and 6” diameter chute
- Glovebox must be inspected for hydraulic fluid prior to use
- Sand chute plug is required to be in place at all times except when transferring sand to the sand separator
- Slag chute plug is required to be in place at all times
- All uranium materials must be removed before another vessel is introduced to the glovebox

Conclusions

- The reduction process had drifted over time and CSE revisions only adjusted analysis and controls for the primary material pathway
- The operator prevented hydraulic fluid from reaching the unfavorable volume sand separator by following his procedure
- Significant physical and administrative changes have been made to prevent liquid intrusion and significant uranium accumulation in the sand separator

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