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Nuclear Fuel Services, Inc.

Credible NCS Accident Sequences

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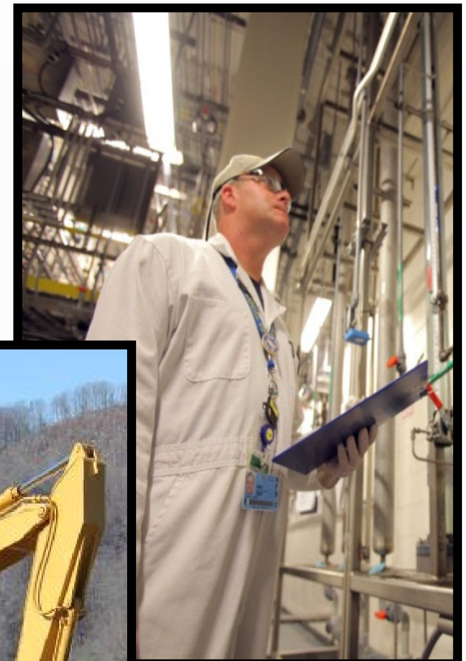
Major Business Lines

- Naval Reactors Fuel
- Naval Reactors Fuel Development
- Downblending
- Decommissioning



Tom McLaughlin Slides

(Relevant to Accident Sequences)

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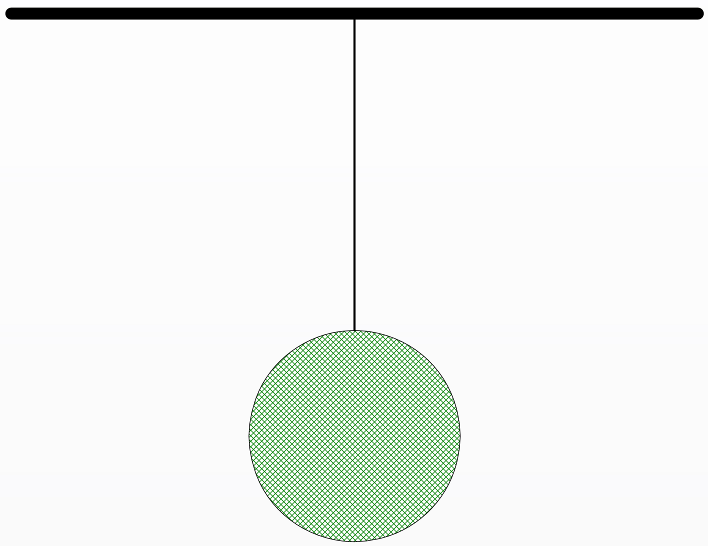
Safety Margin

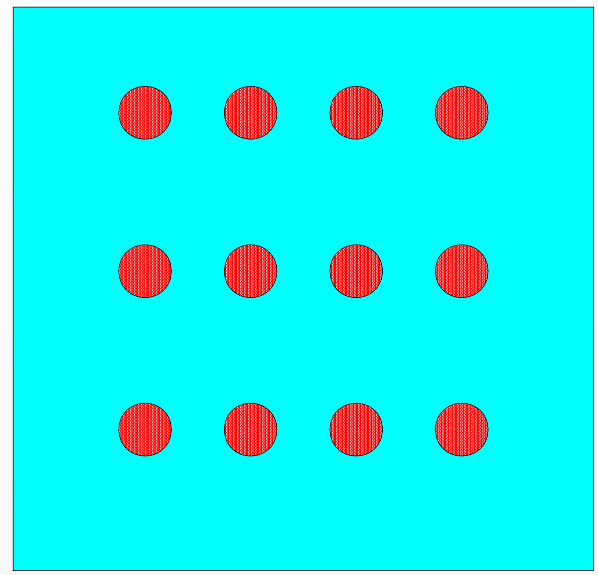
- How does one assess or quantify the safety margin associated with a particular fissile material operation?
  - Δk_{eff}?
  - Δmass?
  - Δvolume?

- **Consider two systems:**



6 kg α-phase ^{239}Pu Sphere

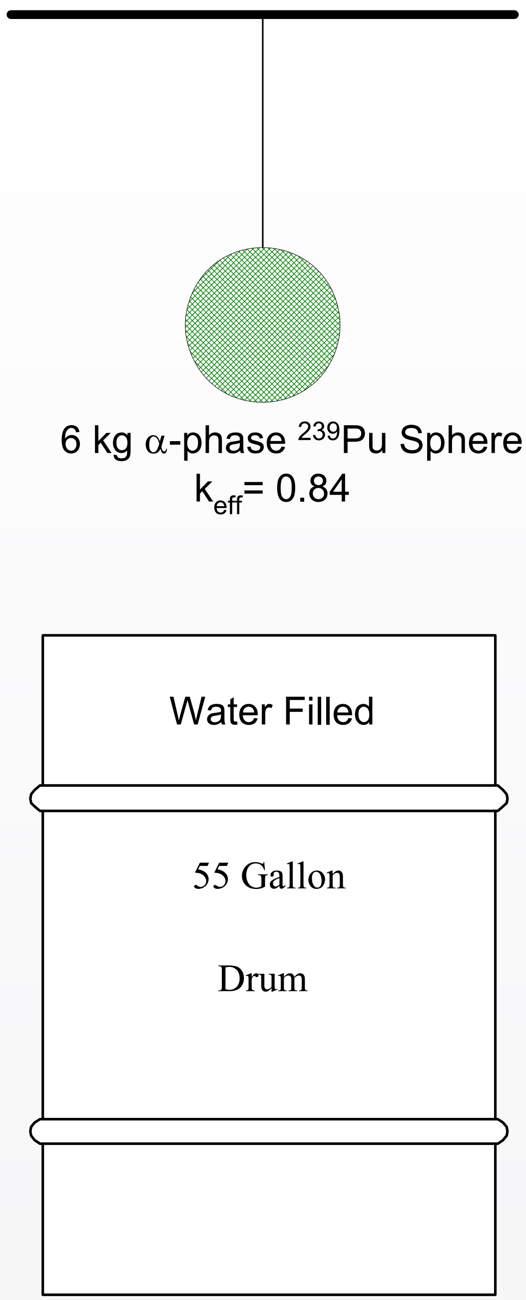
k_{eff}= 0.84



Natural Uranium Rods in Water

k_{eff}= 0.9999

- **Which has the higher safety margin?**


6 kg α-phase 239Pu Sphere
keff= 0.84
Water Filled
55 Gallon
Drum

- Natural uranium rods in water can not be critical.
- The safety margin for the sphere of Pu rests solely with the likelihood that the suspension will hold.
- Safety margin is measured by the effects of credible upsets!
- The primary focus is the identification and control of criticality accident sequences. This is where the action is.

Definition of "Credible"
(Similar to NUREG-1520)

- Credible – An event or accident sequence is considered 'credible' unless it is determined 'Not Credible' by meeting one of the three criteria specified below:

  - An external event whose frequency of occurrence can be qualitatively estimated as having an initiating event frequency index of < -5, or quantitatively determined to be < 1E-6 events per year.

  - A process deviation that consists of a sequence of many unlikely human actions or errors for which there is no reason or motive, excluding intent to cause harm. In order to be considered not credible, no such sequence of events can ever actually have happened in any fuel cycle facility.

  - Process deviations for which there is a convincing argument, based on physical laws or engineering principles that the deviations are not possible, or extremely unlikely. The validity of the argument must not be dependent on any feature of the design or materials which is controlled by the plant's system of IROFS.

How are Sequences Identified?

- Identified through Process Hazards Analyses (PHAs)
- Using methodologies listed in NUREG-1513, “Integrated Safety Analysis Guidance Document”
- Method selected based on the complexity of the process and the severity of the hazards.

Process Hazards Analyses (PHAs)

- PHA Team
- Operations, Safety, Engineering, and other relevant personnel
- Primarily use What-if or HAZOP technique

What-if Table

(Example from NCS Evaluation)

Table 3-1 What-if Hazard Identification for System-D

No.: 1UMD	**Description:** Equipment IACs 701, 815, 819, 825, 841, and 864 Drawings 333-F0400-D and 333-F0401-D dated 04/06/2006 (Includes 333-F0469-D dated 04/06/2006)		
Drawing: 333-F0400-D Rev H dated 3/1/2004, 333-F0401-D Rev I dated 3/1/2004			
Item	**What if...?**	**Causes**	**Consequences**
1.19	Valve fails open	Human error Mechanical failure	Potential spill of solution from equipment-DA/B during maintenance Potential for accumulation of material in unfavorable geometry (Rad/Chem/Crit)
1.44	Nitrogen supply fails high (for Rosemount system during oxidation)	Human error Mechanical failure (regulator)	Potential for solution to enter chemical supply lines, equipment-C, or equipment-E drains. Potential equipment damage Potential spill of equipment-D solution. Potential for accumulation of material in unfavorable geometry. Potential to backflow solution to equipment-BF. Potential to overflow equipment-CO. Potential to overflow equipment-A from equipment-B. Potential to overflow equipment-B from equipment-A Potential to overflow through equipment-BF onto floor (Rad/Chem/Crit)
1.45	Nitrogen supply fails low (for Rosemount system during oxidation or dissolution)	Human error Mechanical failure (regulator)	Potential for equipment-D solution to backflow into nitrogen supply (Crit)
1.47	Nitrogen supply line breaks	Human error Mechanical failure Impact accident	Potential for equipment-D solution spill Potential for accumulation of material in unfavorable geometry (Rad/Chem/Crit)
1.61	Blower fails on	Human error Mechanical failure	Potential for U to enter POG Potential for U in scrubber (Crit)
1.72	Too much U in equipment-F	Human error Mechanical failure	Potential to exceed NCS limits (Crit)
1.73	Incompatible materials in equipment-F	Human error	Potential explosion Potential to exceed NCS limits (Rad/Chem/Crit)
1.77	Too much U in equipment-E	Human error Mechanical failure	Potential to exceed NCS limits (Crit)

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Accident Sequences
(Example from NCS Evaluation)

4.1.30 <u>**SNM Solution Leak Inside Equipment-EF**</u>

[Case # 1.44] - Nitrogen supply fails high (for Rosemount system during processing)

4.1.30.1 Discussion

These What-ifs have the potential to cause solution to be misdirected to the filter enclosure and potentially leak into the filter enclosure if the filters are not installed or not properly installed

4.1.30.2 Double Contingency Analysis

If leak occurred inside equipment-EF concurrently with those upsets necessary to provide a volume sufficient to exceed a subcritical depth, the enclosure is equipped with an SRE drain designed to ensure that the subcritical solution of 5 cm will not be exceeded within the enclosure (**IROFS BUM-44**).

4.1.30.3 Criticality Safety Barriers

- Initiating upset of solution leak inside equipment
- Enabling event of a sufficient volume of solution to exceed the subcritical slab height of 5 cm
- SRE level sensors and isolation valves to limit the solution depth inside equipment-EF to no more than 5 cm. (**IROFS BUM-45**)
- SRE passive drain on the enclosure designed to prevent a solution depth of greater than 5 cm from accumulating on the equipment floor. (**IROFS BUM-44**)

4.1.30.4 Risk Index Assignment

An effectiveness of protection index of -4 is assigned to **IROFS BUM-44**, because the drain line on the enclosure is a robust passive engineered control that is periodically inspected.

Risk Index Table
(Example from NCS Evaluation)

Table 4-1 Accident Sequence Summary and Risk Index Assignment

Accident Sequence	Initiating Events/ Enabling Events (IE / EE)	IROFS EOPI (A-Active, E-Enhanced, P-Passive)	Likelihood Index T	Likelihood Category (LC)	Risk Index (LC x 3)
4.1.28.4.5 SNM Backflow into Plant Air Supply from DI water supply to equipment-D	Loss of supply pressure IE=-1 Motive backflow force EE=-1	BUM-36/BUM-38(**P**) (-4) BUM-37/BUM-39(**P**) (-4) ——— BPF-35(**A**) (-2) ——— BPF-36(**A**) (-2)	T = -14	LC = 1	3
4.1.30 SNM Solution Leak Inside equipment-EF	Leak from Filter/Piping IE=-1 Sufficient Volume of Solution to create slab depth >5 cm EE=-1	BUM-44(**P**) (-4) ——— BUM-45 (**A**) (-3)	T = -9	LC = 1	3

Limits and Controls Table

(Example from NCS Evaluation)

Table 6-1 Limits and Controls

Limit ID	Indicate Control Type ("X")				Components	Safety Control/Limit	Basis for Control/Limit	Accident Sequence
	IROFS	SRE	CCE	ADMIN				
BUM-44(P)	**X**	**X**			DRAINH3F12	Drain on equipment-EF that shall be constructed of materials compatible with the process environment and shall be sufficiently sized (as determined by set-point analysis) based on maximum flow rate (considering credible abnormal conditions) to prevent exceeding a 5-cm solution depth in the enclosure. The overflow shall be designed such that periodic inspections (frequency and method specified in the applicable SRE test) can be performed.	Maintaining the solution depth to no more than 5 cm will remain subcritical based the calculations in **Section 4.2.2.27.**	4.1.30
BUM-45(A)	**X**	**X**			LSH-3F05 LSH-3F06 HV-3F05 HV-3F06 PLC	A system of two level sensors inside enclosure equipment-EF which will detect solution on the enclosure floor. Each sensor shall be interlocked through PLC control to close two isolation valves serially located in the solution transfer line to filter enclosure equipment-EF to prevent exceeding a 5 cm solution depth in the enclosure. The system shall be fail-safe such that the loss of electrical power, plant air, or a PLC malfunction results in both isolation valves closing.	Maintaining the solution depth to no more than 5 cm will remain subcritical based the calculations in **Section 4.2.2.27.**	4.1.30