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Title: NCS Control Efficacy

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NCS Control Efficacy Presentation for EFCOG Conference

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Overview of Presentation

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Background

- ANSI/ANS-8.1 requires that fissionable material operations remain subcritical under normal and credible abnormal conditions (4.1.2)
- For most operations, this means identifying controls that limit one or more of the traditional NCS parameters within a particular range or above/below a certain value
- The effect of variations in these controlled parameters on k_{eff} must be understood (ANSI/ANS-8.1, 4.2.1)

Background

- Selected NCS controls must:
  - Remain within the required range or above/below a specific value and must truly affect the system reactivity
  - Be verifiable by operations personnel
- Failure of controls to meet these criteria can result in consequences that will be discussed below

Non-Implementable/ Unneeded Controls

- Controls selected must be vetted with operations personnel who are the experts
- Controls must be implementable, the parameters they limit be verifiable, and they must not overly inhibit the operation
- This must occur before the criticality safety evaluation is finalized and issued for implementation

Non-Implementable/ Unneeded Controls- Examples

- Vault operations at LANL
  - Engineered controls identified that could not be verified (bin dimensions, spacing requirements)
  - Some controls unclear due to ambiguity in terminology
  - Variations in some controlled parameters had no discernable effect on *keff*
  - Controls were based on MCNP input values without sufficient consideration (effect on reactivity, implementability, etc.)
- Safe operations at LANL
  - Dimensions specified as engineered controls: drawer width, wall thickness, spacing between drawers
  - Again, these were based on MCNP input values without due consideration

Non-Implementable/ Unneeded Controls- Consequences

- Controls that are needed are not effective if they cannot be verified
- Unneeded controls (that do not significantly influence the reactivity) put additional burdens on operations and NCS personnel
- Rework of the NCS evaluation due to these reasons takes time and uses resources without a valid cause

Over-conservatism in Analysis - Unneeded Controls

- NCS engineers need to ensure the analysis bounds the actual operation
- Increased scrutiny of NCS evaluations leads some analysts to make analysis ***so*** conservative that no questions can realistically be asked of whether the analysis is truly bounding
- Over-conservatism can also be used to atone for lack of rigor in developing the credible abnormal conditions
- Regardless of the reason, excessive conservatism can result in identifying controls that are truly not needed to establish the requisite safety margin

Over-conservatism in Analysis Examples

- Using isotopically pure material (100% Pu-239 or 100% U-235)
  - Realistic isotopics can buy up to a few percent in *keff*
- Using idealized solutions (metal-water mixtures)
  - Realistic solutions have ions that serve as diluents and poisons; also can have excess molarity/normality which can increase critical mass
- Using theoretical densities for materials
  - Theoretical oxide or compound densities can be 2, 3, or 4 times higher than bulk or even tap densities
  - Manufactured graphite densities are at least 25% lower than theoretical density
- Non-credible abnormal conditions were analyzed since they are below the USL anyway
- Eliminating these unrealistic conservatisms can save several percent in *keff* if combined

Over-conservatism in Analysis Consequences

- Unnecessary controls may be identified that then need to be implemented, surveilled, and worked within
- Operational throughput may be reduced without a valid reason
- Even if the operation has been shown to be subcritical with excessive conservatism, circumstances could change:
  - Errors could be found in the calculation
  - A new USL could be established whereby the conservatism would have to be removed in a rework of the criticality safety evaluation.
- Margin gained by using realistic parameters could be used in these cases and avoid a rewrite of the evaluation
- Again, rework of the NCS evaluation due to these reasons takes time and uses resources without a valid cause

Conclusion

- Even though controls are necessary in most cases to ensure subcriticality, they must be selected wisely and be defensible
- Many complicated and impressive graphs of results cannot atone for poor control selection in establishment of the control suite for the operation
- Controls must truly be needed and must be implementable
- Control selection must be agreed upon by operations personnel prior to the criticality safety evaluation being finalized