Nuclear Criticality Safety Performance Requirements

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Statement of Problem

- Two different performance requirements in 70.61:
  - (b) Credible high-consequence events (>100 rem) must be highly "unlikely"
  - (d) Subcritical under normal and credible abnormal conditions...approved margin of subcriticality for safety...prevention vs. mitigation

- Baseline design criterion in 70.64 => double contingency principle (DCP)

- Historical ambiguity as to applicability of 70.61(b) and (d): Does (b) apply to criticality?

- Relationship between traditional approach (DCP) and ISA methodology: Does DCP = Highly Unlikely?

Performance Requirements

- 70.61(b) & (d): risk-informed and deterministic approaches to safety
  - Meet 70.61(d) => meet 70.61(b)
  - Meet 70.61(b) + prevention + margin of subcriticality => 70.61(d)
- Regardless whether you start with 70.61(b) or (d), ISA methodology in 70.62 applies
- All items relied on to meet 70.61(b), (c), or (d) must be classified as IROFS

Performance Requirements

- Meeting 70.61(d):
  - Margin may be in terms of k_{eff} or process parameters
  - Focus on preventing all criticality events
  - More restrictive than 70.61(b)
- Meeting 70.61(b):
  - Systematic methodology to ensure all accident scenarios identified
  - Focus on preventing consequences of a criticality

Double Contingency Principle

- 70.64 applies only to new facilities and processes. However...

- Existing fuel facilities have committed to DCP by license

- Relationship between 70.61(d) and 70.64(a)(9):
  - DCP (if robust, as discussed below) one way of ensuring subcritical under normal and credible abnormal conditions
  - Subordinate to ensuring subcriticality (should vs. shall)

- DCP meets 70.61(d) if:
  - Controls used to meet DCP are IROFS
  - Margin of subcriticality acceptable
  - Controls sufficiently robust

Double Contingency Principle

- Historically, a variety of DC protection approaches have been accepted => some may not meet 70.61

- Solution:
  - DC protection not redefined: if previously acceptable, still acceptable
  - DC must be robust to be used as basis for meeting 70.61(b) or (d)

- Examples provided for when DC meets, and does not meet, 70.61

Examples of DC That Could Meet 70.61(d)

- *Single passive control with no credible failure mode*
- *Two passive controls**
- *One passive and one active control**
- *One engineered and one enhanced administrative control**
- *One engineered and one simple administrative control with redundancy**
- *Two administrative controls with "large margins"**
- *Criticality not credible*

  * With appropriate management measures (e.g., failure detection)

Examples of DC NOT Meeting 70.61(d)

- *Simple administrative controls without backup*
- *Ambiguous/confusing controls*
- *Controls too complex*
- *Insufficient margin*
- *No failure detection*
- *Hostile environment*
- *Failure state uncertain*
- *Reliance on undeclared controls*

Conclusions

- Subcritical under credible conditions => Highly Unlikely (i.e., (d) => (b)).
- (b) => (d) *if* preventive strategy used and acceptable margin
- DCP => 70.61(b) & (d) <u>if</u>:
  - ☐ controls are IROFS
  - ☐ margin acceptable
  - ☐ controls sufficiently robust
- Robust double contingency one way of meeting performance requirements