

NRC/NEI Criticality Workshop



Harry D. Felsher
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NCS is Risk-Informed, Performance-Based (R-I,P-B)

- Part 70 is RI-PB
- Aspects of NCS are RI-PB
- R-I = review all operations, more closely at some
- P-B = based on how licensee has operated

NCS in Part 70

- Same as previous Part 70
- New Subpart H

NCS License Review

- Same as previous Part 70, all disciplines, & statements with justification
- For 70.64, Integrated Safety Analysis (ISA) Summary submittal
- NRC does not & has never required submittal of NCS Evaluation

NCS Exemption

- Same as previous Part 70, all disciplines, & statements with justification
- Demonstration of commitments to meet purpose of regulation
- Not acceptable example, site-wide exemption without alternatives

NCS in Performance Requirements

- Current NRC licensees, NCS accident high consequence & must be highly unlikely
- Not High-Consequence event if 70.61(b) not reached
- Also, not Intermediate-Consequence event if 70.61(c) not reached
- All cases, still must meet 70.61(d)

NCS in ISA Summary

- Same as all disciplines & statements with justification

- Broad programmatic commitments NOT sufficient

- 70.24, 70.61, & 70.64

NCS Review of ISA Summary

- Same as all disciplines & statements with justification

- All processes meet regulation thru review of key items

- If regulations not met, then needs revision

**Proposed Changes to 10 CFR
Part 71 Involving Criticality
Safety**



Andrew Barto (ABB2@nrc.gov)
Spent Fuel Project Office
U.S. Nuclear Regulatory Commission

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Overview

- Introductions
- Rulemaking Status
- Proposed Changes to Part 71 Criticality Requirements
- Questions

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**10 CFR Part 71 Rulemaking
Status**

- Completed Public Comment
- Final Rule package to the Commission - August 15, 2003
- Awaiting Commission approval

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**Proposed Changes to Part 71
Criticality Requirements**

- Uranium Hexafluoride (UF₆) Package Requirements
- Criticality Safety Index (CSI)
- Fissile Material Exemptions and General Licenses

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UF₆ Package Requirements

- UF₆ packages excepted from §71.55(b) requirement to consider in-leakage of water provided that there is:
 - No contact between valve body and cylinder during hypothetical accident conditions tests in §71.73,
 - Adequate quality control in the manufacture, maintenance, and repair of packagings,
 - Testing to ensure closure prior to each shipment
 - Maximum 5 weight-% ²³⁵U in contents

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**UF₆ Package Requirements
(cont'd)**

- Changed to be consistent with IAEA Regulations for the Safe Transport of Radioactive Material (TS-R-1)
- Codifies current worldwide practice in shipping fissile UF₆ cylinders
- Consistent with ANSI N14.1 and ISO 7195 standards, and DOT regulations

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Criticality Safety Index (CSI)

- Determined the same way as the transport index for criticality control in §71.59:
 - $CSI = 50/N$, where a limiting number of packages "N" is derived from the consideration of subcritical arrays of 5N undamaged packages and 2N damaged packages

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Criticality Safety Index (cont'd)

- Increased the CSI per package limit from 10 to 50 for fissile material packages in nonexclusive use shipments
- Per package CSI limit remains 100 for exclusive use shipments
- CSI must be displayed on fissile material packages using a new "fissile material" label.

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Fissile Material Exemptions and General License Provisions

- Feb., '97 Rulemaking restricted special moderators in exempt packages
- Restrictions viewed as too limiting – resulted in exclusion of some inherently safe packages from fissile exemption
- NUREG/CR-5342: ORNL reviewed exemption/general license provisions, performed calculations for mixtures of different fissile materials and moderators

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Fissile Material Exemptions and General License Provisions

- Fissile exemptions revised from §71.53 to include controls on fissile package mass limit combined with package fissile-to-nonfissile mass ratio
- General License for fissile material revised to simplify current provisions from set of general licenses in §71.18 through §71.24

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New Part 71 Provisions

- §71.15 Exemption from classification of fissile material
- §71.22 General license: Fissile material
- §71.23 General license: Plutonium-beryllium special form material

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§71.15 Exemption from Classification as Fissile Material

- (a) Individual or bulk packaging with $\leq 15g$ fissile material, provided mass ratio of iron to fissile material ≥ 200
 - Provides criticality protection for large numbers of packages, each with up to 15g fissile material, due to fissile material dilution

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§71.15 Exemption from Classification as Fissile Material

- (b) Low concentrations of solid fissile material mixed with nonfissile material such that: (i) nonfissile to fissile ratio ≥ 2000 , (ii) $\leq 350\text{g}$ fissile material per package
 - Lead, beryllium, graphite, and deuterium not included in nonfissile mass determination
 - Provides criticality protection for large packages with low fissile concentrations

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§71.15 Exemption from Classification as Fissile Material

- §71.53(b) moved to §71.15(c): Uranium enriched up to 1%
- §71.53(c) moved to §71.15(d): UNH enriched up to 2%
- §71.53(d) moved to §71.15(e): $\leq 1000\text{g}$ plutonium

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§71.22 General License: Fissile Material

- Consolidation of current general licenses in §71.18 through §71.24
- Provisions for Pu-Be special form sources in separate general license (§71.23)

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§71.22 General License: Fissile Material

- Must be in a Type A package
- Less than a Type A quantity of material
- Less than 500g of special moderators
- $CSI \leq 10$ for individual package, as determined in paragraph (e)

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§71.23 General License: Pu-Be Special Form Material

- Must be in a Type A package
- Less than a Type A quantity of material
- Less than 1000g Pu, with $^{239}\text{Pu} + ^{241}\text{Pu}$ less than 240g
- $CSI \leq 100$ for individual package

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§71.22 General License: Fissile Material

- CSI determined using equation:

$$CSI = 10 \left[\frac{\text{grams of } ^{235}\text{U}}{X} + \frac{\text{grams of } ^{233}\text{U}}{Y} + \frac{\text{grams of Pu}}{Z} \right]$$

- X, Y, and Z determined from Table 71-1 when ^{239}U present, Pu present > 1% of ^{235}U , or ^{235}U enrichment > 24% or unknown
- X determined from Table 71-2 otherwise

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**§71.23 General License: Pu-Be
Special Form Material**

- CSI determined using equation:

$$CSI = 10 \left[\frac{\text{grams of } ^{239}\text{Pu} + \text{grams of } ^{241}\text{Pu}}{24} \right]$$

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**§71.15 Exemption from
Classification as Fissile Material**

- (a) Individual package containing ≤2g fissile material
 - Intended to encompass small quantities of fissile materials, such as environmental samples shipped for testing
 - Risk of accumulating enough packages for criticality hazard judged to be inconsequential

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**§71.15 Exemption from
Classification as Fissile Material**

- (b) Individual or bulk packaging with ≤15g fissile material, provided ratio of solid nonfissile material to fissile material ≥200
 - Lead, beryllium, graphite, and deuterium not included in nonfissile mass determination
 - Provides criticality protection for large numbers of packages, each with up to 15g fissile material, due to fissile material dilution

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**§71.15 Exemption from
Classification as Fissile Material**

■ (c) Low concentrations of solid fissile material mixed with nonfissile material such that: (i) nonfissile to fissile ratio ≥ 2000 , (ii) $\leq 180\text{g}$ fissile material per 360 kg of nonfissile material

- Lead, beryllium, graphite, and deuterium not included in nonfissile mass determination
- Provides criticality protection for large packages with low fissile concentrations

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Margaret S. Chatterton
September 25, 2003

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**NRC Regulations Pertaining to
Criticality**

- 70.22 Contents of Applications
- 70.23 Requirements for the Approval of Applications
- 70.24 Criticality Accident Requirements

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**NRC Regulations Pertaining to
Criticality**

- 70.61 Performance Requirements
- 70.62 Safety Program and Integrated Safety Assessment
- 70.64 Requirements for New Facilities
- 70.65 Additional Content of Applications

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Nuclear Criticality Safety Regulations

- Criticality Accident Requirements: 70.24
- Performance Requirements: 70.61(b) and (d)
- Baseline Design Criteria: 70.64(a)(9)

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70.24 Criticality Accident Requirements

- Apply if amount of SNM exceeds
 - 700 gm Uranium 235
 - 450 gm Plutonium
- Qualified monitoring system
 - Gamma or neutron-sensitive radiation detectors
 - Audible alarms
 - Capable of detecting a criticality
 - Coverage by two detectors
- Emergency Procedures

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70.61 Performance Requirements

- 70.61(b) Criticality is Highly Unlikely
- 70.61(d) Under Normal and Credible Abnormal Conditions
 - All nuclear processes are subcritical
 - Including use of an approved margin of subcriticality
- Preventive controls and measures
 - Primary means of protection

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70.64 New Facility and Process Requirements

- **70.64(a)(9) Double Contingency Principle**
 - Two
 - Unlikely
 - Independent
 - Concurrent
 - Changes in process conditions
 - Before criticality possible

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Standard Review Plan (SRP) for the Review of Fuel Cycle Facility NUREG-1520

- **Guidance for review and evaluation**
 - New applications for possession and use of SNM
 - License amendments
 - License renewal applications

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SRP for the Review of Fuel Cycle Facilities: NUREG-1520

- Ensures the quality and uniformity
- Improves communication and understanding of review and regulatory process
- Regulatory guidance for applicants and staff

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SRP for the Review of Fuel Cycle Facility NUREG-1520

- Purpose of Review
 - NCS program adequate
 - NCS program to ensure safe operation of facility
 - Examine controls & barriers
 - Relied on to prevent criticality
 - Designated as IROFS

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American National Standards Institute/American Nuclear Society 8 Series Standards (ANSI/ANS-8.xx)

- Consensus Standards Specific to Criticality Safety
- Developed by Working Groups
 - Industry Representatives
 - NRC Licensees
 - DOE Facilities
 - Regulatory Representatives
 - NRC
 - DOE

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**US NRC REGULATORY GUIDE 3.71:
Nuclear Criticality Safety Standards for Fuels and Material Facilities**

- Purpose
 - Provide guidance
 - Describe procedures
- Endorsement of specific standards
- Consolidates and replaces previous guidance
- Procedures & methodology generally acceptable

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US NRC REGULATORY GUIDE 3.71

(Continued)

- Not substitute for NCS analysis
- Commitment to standard
 - All operations in accordance with requirements
 - Recommendations not followed; then justification

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US NRC REGULATORY GUIDE 3.71

(Continued)

- Deviations/Modifications from Standards
 - ANSI/ANS-8.1 Section 4.3.6 validation details
 - Adequacy of margins of subcriticality
 - Bias
 - Criticality parameters
 - Demonstrate range of variables
 - Demonstrate trends in bias for extensions

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US NRC REGULATORY GUIDE 3.71

(Continued)

- Deviations/Modifications from Standards
 - ANSI/ANS-8.3
 - Section 4.2.1
 - Standard - evaluation
 - Regulatory Guide - requires
 - Section 4.5.1
 - Standard - 1 detector
 - Regulatory Guide - 2 detectors
 - Section 5.6
 - Standard - documenting different minimum accident
 - Regulatory Guide - specifies system requirements

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US NRC REGULATORY GUIDE 3.71
(Continued)

- Deviations/Modifications from Standards

- ANSI/ANS-8.10

- Section 4.2.1

- Standard - source strength and release estimates by analysis

- Regulatory Guide - specifies source strength and releases; less conservative requires justification

- ANSI/ANS-8.17

- Standard- allows burnup credit

- Regulatory Guide- burnup credit only by measurement

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Christopher S. Tripp
September 25, 2003

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Double Contingency and 10 CFR 70.61

- 70.64(a)(9): "...at least 2 **unlikely**, independent, and concurrent changes..."
- 70.61(b): high-consequence events => "**highly unlikely**"
- 70.61(d): normal and credible abnormal events => subcritical
- Regulations:
 - 70.61 met by all licensees
 - 70.64 met for new facilities/processes
 - 2 requirements not equivalent

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Double Contingency and 10 CFR 70.61

- "Unlikely" for DCP:
 - NUREG-1718, Section 6.4.3.3.5(C): ≠ "unlikely" from 70.61(C)
 - 70.61(C): $\leq 10^{-4}$ /event/yr (NUREG-1520, Section 3.4.3.2(9))
 - DCP:
 - $\leq 10^{-5}$ /event/yr; "expected rarely during the lifetime of the facility, if at all" (NUREG-1718, Section 6.8)
 - "Not anticipated to occur during the lifetime of the facility"
- "Highly Unlikely": $\leq 10^{-5}$ /event/yr (NUREG-1520, Section 3.4.3.2(9))

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Double Contingency and 10 CFR 70.61

- HU = "a system of IROFS that possesses double-contingency protection, where each of the applicable qualities is present to an appropriate degree." (NUREG-1520, Section 3.4.3.2(9))
- Refers to "availability and reliability qualities" of IROFS and systems of IROFS
- Qualitative methods acceptable if:
 - Reasonable clear and based on objective criteria
 - Can reasonably be expected to consistently distinguish accidents that are highly unlikely from those that are merely unlikely

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Double Contingency and 10 CFR 70.61

- DCP that meets HU:
 - DC where failure of each criticality IROFS is "unlikely"
 - Likelihood based on described availability and reliability qualities
 - Reliability ensured by management measures, industry standards, and QA Plan
 - Additional assurance provided by one of following:
 - Failure detection = on sufficient frequency to reduce likelihood by a substantial amount
 - Additional safety margin = requires multiple failures for criticality
 - Other margin/defense-in-depth

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Defense-in-Depth & Additional Margin

- 70.61(e): relied on to meet 70.61 => IROFS; must ensure reliable and available to perform intended function
- Needed to ensure IROFS reliable and available => IROFS
- Other design/process features provide additional defense-in-depth
- Not credited for NCS or ISA if not controlled as IROFS

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