UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 3, 2002

MEMORANDUM TO: Melvyn N. Leach, Chief
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
and Safeguards

THRU: Joseph G. Giitter, Chief **/RA/**
Enrichment Section
Special Projects and Inspection Branch, FCSS

FROM: Timothy C. Johnson **/RA/**
Senior Mechanical Systems Engineer
Enrichment Section
Special Projects and Inspection Branch, FCSS

SUBJECT: MARCH 27, 2002, MEETING SUMMARY: MIXED OXIDE FUEL FABRICATION FACILITY CRITICALITY AND LICENSING REVIEW ISSUES

On March 27, 2002, U.S. Nuclear Regulatory Commission (NRC) staff met with Duke Cogema Stone & Webster (DCS) staff to discuss criticality and licensing review issues. I am attaching the meeting summary for your use.

Docket: 70-3098

Attachment: Mixed Oxide Fuel Fabrication Facility Criticality and Licensing Review Issues Meeting Summary

cc: Mr. Peter Hastings, DCS
Mr. James Johnson, DOE
Mr. Henry Potter, SC Dept. of H&EC
Mr. John T. Conway, DNFSB
Mr. Louis Zeller, BREDL
Ms. Glenn Carroll, GANE

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Attachment: Mixed Oxide Fuel Fabrication Facility Seismic Meeting Summary

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Mr. Louis Zeller, BREDL
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Mixed Oxide Fuel Fabrication Facility Criticality and
Licensing Review Issues Meeting

Date: March 27, 2002

Place: U.S. Nuclear Regulatory Commission (NRC) offices; Rockville, MD

Attendees: See Attachment 1

Purpose:

The purpose of this meeting was to discuss criticality safety issues and review the status of outstanding licensing open items related to the review of the Mixed Oxide (MOX) Fuel Fabrication Facility construction application.

Discussion:

Following the introduction of meeting attendees, NRC staff presented information on the following two open licensing items applicable to nuclear criticality safety (see Attachment 2):

1. Ensuring criticality is "highly unlikely," and
2. Qualifications for criticality staff.

For defining "highly unlikely," NRC staff summarized the following acceptance criteria drawn from existing guidance (NUREG-1520, ""Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," and NUREG-1718, "Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility."):

1. Criteria should be developed for evaluating accident sequences and items relied on for safety (IROFS), rather than broad programmatic commitments;

2. Criteria should be based on objective qualities of IROFS;

3. Criteria should be expressed in terms of relevant reliability and availability characteristics of a system of IROFS;

4. Criteria should consistently distinguish between likelihood categories; and

5. Criteria should be consistent with the quantitative guideline of less than 1E-5/year.

NRC staff expects that the application of the above criteria with the double contingency principle will result in a reasonable approach for defining "highly unlikely."

Duke Cogema Stone & Webster (DCS) took the approach of preventing criticalities such that a criticality event would be highly unlikely. DCS also took a qualitative rather than a quantitative approach for demonstrating that a criticality is highly unlikely. For nuclear criticality accident scenarios, DCS stated that "highly unlikely" will be demonstrated by addressing for each scenario the specific initiating event, items relied on for safety (IROFS), bases for double contingency, applicable codes and standards, and methods for detecting IROFS failure. In addition, DCS committed to perform a systematic analysis of IROFS effectiveness. This systematic analysis would consider reliability characteristics such as failsafe conditions, human factors, and environmental considerations. The NRC staff stated that DCS should describe that it will take into account all reliability and availability characteristics that can affect likelihood (*e.g.*, defense-in-depth, redundancy, independence, diversity, and vulnerability to common-cause failures).

DCS staff discussed their proposed method for evaluating the likelihood of potential criticality events (see Attachment 3). The DCS objective is to use deterministic criteria that would satisfy the Integrated Safety Assessment (ISA) requirements in 10 CFR 70.61. DCS would apply the single failure criteria and double contingency principle, industry-specific codes and standards, the 10 CFR Part 50, Appendix B quality assurance criteria, and programs to detect IROFS failures and to identify IROFS repair and safe system shutdown features. DCS would also conduct appropriate maintenance activities to ensure that criticality systems function properly and can be relied on when needed. The ISA would provide a summary of the process hazards analyses and provide information on an event-by-event basis consistent with the qualitative guidance provided in NUREG-1718. DCS committed to use codes and standards for structures, systems, and components that exceed commitments of current operating facilities. It also committed to using a 10 CFR Part 50, Appendix B, quality assurance program and committed to demonstrate in an ISA the effectiveness of the IROFS and that each criticality sequence is highly unlikely through detailed event descriptions and analysis. The NRC staff stated that the outlined approach appeared to be generally acceptable, but that DCS should submit a more detailed discussion for review, describing its approach for assigning controls to likelihood categories and determining acceptability.

In the area of criticality safety qualifications, DCS had proposed qualification requirements for the positions of nuclear criticality safety function manager, senior engineer, and engineer. According to DCS, these position requirements are based on experience with nuclear criticality safety, but do not require MOX-specific experience because little MOX experience is available. NRC staff stated that MOX/Pu experience (knowledge of plutonium properties and processing) should be specified to ensure that criticality safety engineers involved in the design of the Mox Fuel Fabrication Facility have the appropriate level of qualifications. DCS staff indicated that the physics of criticality safety is common between uranium and plutonium applications, and therefore, it should be unnecessary to require MOX-specific experience. DCS did, however, acknowledge that there are nuances to plutonium versus uranium that must be taken into consideration, and therefore, it is using Cogema experience from French MOX programs in its system design. DCS stated that it would think further on the issue as to what it could provide in the way of additional assurance.

DCS also asked about the status of the subcritical margin issue; the NRC staff responded that it was not ready to discuss this in detail but would have a teleconference to discuss its findings in the near future. Regarding the scope of this issue, DCS stated its belief that the scope of the NRC review was limited to a determination of the adequacy of the administrative margin. The NRC staff stated that it considered the Upper Subcritical Limit (including bias, uncertainty in the bias, and administrative margin) part of the design basis of the facility.

A. Persinko discussed the NRC list of open items that would be included in the MOX draft Safety Evaluation Report. Open items are in the areas of corporate organization, site description, financial qualifications, safety analysis of the design basis, nuclear criticality safety, chemical safety, fire safety, radiation safety, environmental systems, civil-structural, aqueous polishing, ventilation, and material and fluid transport. DCS staff indicated that they would ensure that their listing was consistent.

Action Items:

DCS to verify its list of open items is consistent with items presented by NRC staff.

DCS to provide a detailed description of its approach for ensuring that criticality events are "highly unlikely."

Attachments:
1. Attendee List
2. Nuclear Criticality Safety Open Items
3. DCS Methods for Evaluating the
   Likelihood of Potential Criticality Events

ATTENDANCE LIST

NRC - DCS MEETING ON
MIXED OXIDE FUEL FABRICATION FACILITY
MARCH 27, 2002

NAME	ORGANIZATION	PHONE
Andrew Persinko	NRC	
Bill Gleaves	NRC	
Ken Ashe	DCS	
Vincent Chevalier	DCS	
Jamie Johnson	DOE	
Tommy Touchstone	DCS	
Peter Hastings	DCS	
Keat Sullivan	WSRC (by phone)	
Sam Glenn	DOE (by phone)	
Keys Niemer	DCS	
Bob Foster	DCS	
Gary Kaplan	DCS	
Marc Klasly	DCS	
Rex Wescott	NRC	
Christopher Tripp	NRC	
Margaret Chatterton	NRC	
Eric Leeds	NRC	
Norman Fletcher	DOE/NNSA	
Mike Lamastra	NRC	

Attachment 1

ATTENDANCE LIST

NRC - DCS MEETING ON
MIXED OXIDE FUEL FABRICATION FACILITY
MARCH 27, 2002

NAME	ORGANIZATION	PHONE
Wilkins Smith	NEI	
Felix Killar	NEI	
Clifton Farrell	NEI	
Fred Burrows	NRC	
John A. Calvert	NRC	
Tim Johnson	NRC	
Joel Kramer	NRC	
Herman Graves	NRC	
Joe Roarty	DNFSB	
Robyn Bektor	NUMARK	
Ellen Poteat	NRC	
Harold Scott	NRC	
Donald Palmrose	ATL INTERNATIONAL	
Vanice A. Perin	NRC	
Daniel Horner	MCGRAW-HILL	
Frank Motley	LANL	
Don Williams	ORNL	
Don Silverman	MORGAN LEWIS	
Tom Clements	NUCLEAR CONTROL INSTITUTE	
David Brown	NRC	

NEI - Nuclear Energy Institute
DNFSB - Defense Nuclear Facilities Safety Board
ORNL - Oak Ridge National laboratory

Nuclear Criticality Safety (NCS) Issues Associated with the MOX Construction Authorization Request

Christopher S. Tripp, Senior Nuclear Process Engineer (Criticality)
NMSS/FCSS/SPB

March 27, 2002 Public Meeting

Attachment 2

Summary of Open Items

As of March 27, 2002, the following open items existed:

- Method for ensuring criticality is "highly unlikely" (RAI 40/41)
- Appropriate level of MOX/Pu experience for NCS engineers involved in MFFF design (RAI 68)
- Administrative margin/Upper Subcritical Limit for k_{eff} calculations
- Justification for bounding MOX and PuO_2 powder densities (RAI 83)
- Clarification of commitments to ANSI standards (RAI 90)
- NCS control parameters for auxiliary systems impacted by main process

Summary of Open Items

- For each open issue:
  - Applicable regulatory requirements
  - Available guidance and/or precedent
  - DCS' current proposed solution
  - Staff assessment of DCS proposal/what additional information needed for resolution

1. Definition of "Highly Unlikely" for NCS Accident Scenarios

- §70.61(b) "The risk of each credible high-consequence event must be limited. Engineered controls, administrative, or both, shall be applied to the extent needed to reduce the likelihood of occurrence of the event so that...the event is highly unlikely..."

- §70.61(d) "In addition to complying with paragraphs (b) and (c) ...under normal and credible abnormal conditions, all nuclear processes are subcritical..."

- §70.64(a)(9) "The design must provide for criticality control including adherence to the double contingency principle."

§70.64(a): 2 separate requirements. New facilities must meet both §70.61 ((b) and (d)) and §70.64; all facilities must meet §70.61.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- NUREG-1718, Section 5.4.3.2(B)(viii):
  - Quantitative or qualitative definitions of likelihood acceptable.
  - Qualitative definitions acceptable if:
    - "(1) Reasonably clear and objective; and
    - "(2) Reasonably consistent with the quantitative guidelines in this section." (*i.e.*, comparable level of risk)
  - Quantitative guideline for "highly unlikely"on order of 10^{-5}/accident/yr.
  - Guidance in ISA Chapter applies to all safety disciplines.

- NUREG-1718, Appendix A:
  - Worked quantitative ("index method") example.
  - "Highly unlikely" quantitatively < 10^{-5}/accident/yr.
  - Tables A-4 and A-5 include examples of quantitative and qualitative likelihood descriptors.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- Draft NUREG-1520, Section 3.4.3.2(9):
  - Qualitative definition identifies qualities of IROFS that make a sequence "unlikely" or "highly unlikely".
  - Qualitative definitions acceptable if:
    - "(a) Reasonably clear and based on objective criteria; and
    - "(b) Can reasonably be expected to consistently distinguish accidents that are highly unlikely from those that are merely unlikely."
  - "Objective criteria" = specific identifiable characteristics of a process design.
  - "Consistency" = that the same results will be obtained by different analysts.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- Examples (not exhaustive) of reliability and availability qualities to be used in qualitative determinations are given.
- Sample reliability and availability qualities of IROFS:
  - (1) Safety margin
  - (2) Type of control (passive, active, simple or augmented administrative)
  - (3) Type and safety grading of management measures
  - (4) Down-time
  - (5) Failure modes
  - (6) Demand rate
  - (7) Failure rate; *etc.*

Definition of "Highly Unlikely" for NCS Accident Scenarios

For accident sequences: defense-in-depth; degree of: redundancy, independence, diversity, vulnerability to common-cause failure

- "A purely qualitative method...is acceptable if it incorporates all of the applicable reliability and availability qualities to an appropriate degree."

- "One acceptable definition of 'highly unlikely' is a system of IROFS that possesses double-contingency protection, where each of the applicable qualities is present to an appropriate degree."

- Quantitative guideline < 10^{-5}/event/yr

Definition of "Highly Unlikely" for NCS Accident Scenarios

- December 5, 2001, guidance letter:
  - Performance requirements (§70.61) and DCP (§70.64(a)(9)) are two separate requirements that must be independently met.
  - Reference to NUREG-1718
  - ISA Plans for NFS and BWXT approved; both use quantitative index method.
  - General programmatic commitments are too ambiguous to ensure criticality is highly unlikely.

- NUREG-1520 also meets Part 70 and provides useful guidance for non-MOX-specific items.

- NFS and BWXT ISA Plans approved.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- DCS has proposed (Response to RAI 39):
  - Highly Unlikely - *Events...to which sufficient principal SSCs are applied to further reduce their likelihood to an acceptable level...*
  - Site worker and public:
    - Single-failure criterion (DCP for criticality)
    - 10 CFR 50 Appendix B, NQA-1
    - Industry Codes and Standards
    - Management Measures
    - Supplemental likelihood assessment based on NUREG-1718, with target likelihood index comparable to a score of "-5" as defined in Appendix A.
  - Facility workers:
    - Deterministic controls without likelihood assessment.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- In March 8, 2002, letter, DCS defined "unlikely" for DCP as on the order of 10^{-2}/yr.

- Current staff assessment:

  - DCP not sufficient to guarantee "highly unlikely" (§70.61 and §70.64 are two separate requirements)

  - DCP + QA/Management Measures + Standards not sufficiently detailed to guarantee "highly unlikely", for following reasons...

Definition of "Highly Unlikely" for NCS Accident Scenarios

Difficulties with DCP+QA/Management Measures + Standards

- Likelihood is a function of the accident sequences and IROFS; different accident sequences can meet DCP but have different likelihoods.
- Combination of 2 "unlikely" events for DC = $10^{-2} \times 10^{-2} = 10^{-4}$/yr. Not reasonably consistent with quantitative guidelines in NUREG-1718.
- Broad programmatic commitments are not sufficiently detailed; doesn't describe process for evaluating specific QA and management measures to be applied to specific IROFS.
- QA, Management Measures, and standards essential part of NCS Program; not specific to meeting performance requirements of §70.61.
- ANSI standards (including definition of DCP) consensus standards with broad latitude in choosing controls.

Definition of "Highly Unlikely" for NCS Accident Scenarios

- Acceptable qualitative definition of "highly unlikely":
  - Criteria in process for evaluating specific accident sequences and IROFS, rather than broad programmatic commitments;
  - Reasonably clear and based on objective qualities of IROFS;
  - Expressed in terms of all relevant reliability and availability qualities/characteristics of a system of IROFS
  - Capable of consistently distinguishing between likelihood categories
  - Reasonably consistent with quantitative guideline of $< 10^{-5}$/yr.

- *DCP + qualitative descriptors describing degree to which the reliability/availability qualities of a system of IROFS present*

Definition of "Highly Unlikely" for NCS Accident Scenarios

- Partial list of relevant system characteristics --> NUREG-1520, Section 3.4.3.2(9)

- Qualitative description of sample levels/degrees of IROFS --> NUREG-1718, Appendix A, Tables A-4,-5.

2. Appropriate MOX/Pu Experience for NCS Design Staff

- §70.62(a) "Each licensee or applicant shall establish and maintain a safety program that demonstrates compliance with...§70.61."
- NUREG-1718, Section 6.4.3.1, identifies NCS Program as an essential part of implementing the safety program of §70.62(a).
- Heavy reliance for safety in design and operations placed on the NCS Program at fuel facilities; relies on judgement and experience of qualified staff.

- SRP does not describe specific experience levels for a MOX fuel facility
- Guidance letter dated November 9, 2001 included precedent on appropriate NCS staffing qualifications at other NRC-regulated fuel facilities (including NUREG-1520).

Appropriate MOX/Pu Experience for NCS Design Staff

- DCS proposed (March 8, 2002 clarification letter):
  - NCS Function Manager = BS/BA degree in nuclear science or engineering, at least 3 years nuclear industry experience in NCS, and experience in the understanding, application, and direction of NCS programs and familiarity with NCS programs at similar facilities.
  - NCS Senior Engineer = BS/BA degree in science or engineering, and at least 3 years nuclear industry experience in NCS.
  - NCS Engineer = BS/BA degree in science or engineering, and at least 1 year nuclear industry experience in NCS.
- Issues unique to MOX facility:
  - No facility-specific experience available
  - Other industry experience likely to be limited to uranium processing environment

Appropriate MOX/Pu Experience for NCS Design Staff

- NRC believes that MOX/Pu specific experience needed, because:
  - This is a new facility, without established knowledge/experience base on which to draw, to maintain institutional knowledge.
  - Most domestic nuclear industry experience related to LEU/HEU.
  - Nuances associated with different neutronic and physicochemical characteristics of Pu.
  - Traditional dependence on engineering judgement of analyst.

- While NRC agrees that the principles of criticality safety are the same across the nuclear industry, "skill-of-the-craft" and judgement (from experience) are essential components of NCS Program.

DUKE COGEMA
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Method for Evaluating the Likelihood of Potential Criticality Events

Presentation to NRC Staff
27 March 2002

Attachment 6

Presentation Purpose

DUKE COGEMA
STONE & WEBSTER

- Present deterministic likelihood criteria described in the CAR
- Describe information to be presented in the ISA Summary to support the likelihood demonstration
- Demonstrate that application of these deterministic criteria in the ISA will satisfy the performance requirements of 10 CFR 70.61

Summary of Regulations Related to Likelihood Requirements

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- 10CFR70
  - Describes likelihood requirements as a function of the consequence to the dose receptor
  - Requires applicant to define likelihood categories for all events
  - Does not require quantification of event likelihood
- Construction Authorization Report
  - Identifies likelihood definition and criteria
- Integrated Safety Assessment
  - Demonstrates criteria are met on event sequence basis

Highly Unlikely Definition Described in CAR

DUKE COGEMA
STONE & WEBSTER

- Events originally classified as *Not Unlikely* or *Unlikely* to which sufficient principle SSCs are applied to further reduce their likelihood to an acceptable level
- Committed to:
  - Application of single failure criteria or double contingency principle for criticality events
  - Application of industry-specific codes and standards to IROFS (e.g., IEEE, ASME)
  - Application of 10CFR50 Appendix B, NQA-1 QA program to IROFS (18 criteria)
  - Detection of IROFS failures and IROFS repair or safe system shutdown
- CAR also committed to appropriate maintenance programs

Information to Be Presented in the ISA

DUKE COGEMA
STONE & WEBSTER

- Summary of detailed process hazards analysis
- On an event by event basis
  - describe event
  - identify IROFS
  - demonstrate double contingency principle is satisfied
  - identify applicable codes and standards
  - describe method for detection of IROFS failure
  - systematic analysis to demonstrate IROFS are effective

    information consistent with the qualitative guidance provided in SRP 1718

Model Illustrating Application of Likelihood Methodology

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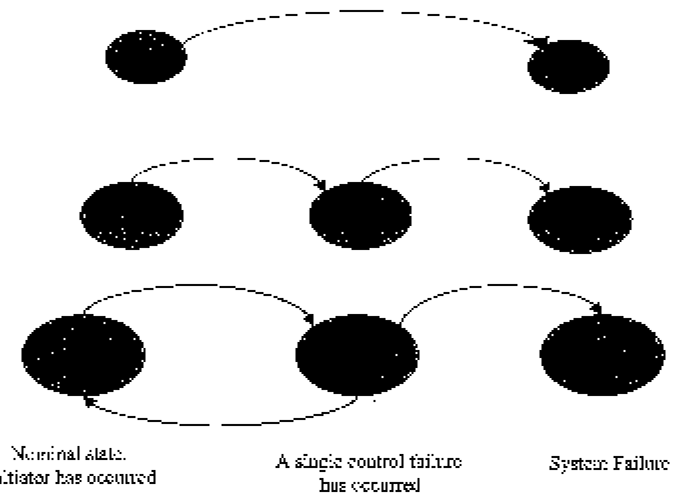
Model 1:
Single Control Model

Model 2:
Double Contingency Model

Model 3 (MFFF):
Double Contingency and
Failure Detection



Approximate Failure Frequencies for Model 3 (per year)

DUKE COGEMA STONE & WEBSTER

--Detection of IROFS Failure--

IROFS Rel #	continuous	per shift	per week	per month	none
0.1	***apprx. 0***	***2E-5***	4E-4	2E-3	2E-2
0.01	***apprx. 0***	***2E-7***	***4E-6***	***2E-5***	2E-4
0.001	***apprx. 0***	***2E-9***	***4E-8***	***2E-7***	***2E-6***

Conclusion (1of 2)

DUKE COGEMA STONE & WEBSTER

- DCS has committed to codes and standards for SSCs that exceed the commitments of current operating facilities
- DCS has committed to a 10CFR50 Appendix B QA program with ample precedent of providing additional assurance in design and operation of SSCs
- DCS has committed to demonstrate in a systematic ISA:
  - the effectiveness of IROFS:
    - demonstrate IROFS are capable of performing safety function
    - analysis of effects NPH, environmental conditions, fail safe positions, loss of utilities, human factors
  - each criticality sequence is highly unlikely through detailed event descriptions that include:
    - event sequence
    - IROFS identification, function, description, detailed parameters
    - demonstration of meeting double contingency including independence
    - description of method for detection of IROFS failure

Conclusion (2 of 2)

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- A general proof demonstrates that application of these commitments can readily satisfy the likelihood requirements for potential high consequence events
- Deterministic method is consistent with NRC licensing basis for other facilities, is consistent with guidance that qualitative demonstrations of likelihood are acceptable, and is consistent with this risk informed rule
- The Staff should be able to conclude that the commitments above provide reasonable assurance that the ISA will demonstrate criticality events are highly unlikely