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AIRBORNE EXPRESS
RETURN RECEIPT REQUESTED

21G-03-0074
GOV-01-55-04
ACF-03-0097

March 13, 2003

Director
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

References:
1) Docket No. 70-143; SNM License 124
2) Letter from B. M. Moore to NRC, License Amendment Request to Support the Uranyl Nitrate Building at the BLEU Complex, dated February 28, 2002 (21G-02-0051)
3) Letter from B. M. Moore to NRC, Reply to Request for Additional Information Concerning Nuclear Criticality Safety Evaluation and Integrated Safety Analysis Summary for the Uranyl Nitrate Building, dated February 10, 2003 (21G-03-0039)
4) Letter from B. M. Moore to NRC, Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building, Revision 2 (Proprietary), dated March 10, 2003 (21G-03-0069)

Subject: Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building, Revision 2 (Non-Proprietary Version)

Dear Sir:

Nuclear Fuel Services, Inc. (NFS) hereby submits the subject Nuclear Criticality Safety Evaluation that contains non-proprietary information and should not be withheld from public disclosure. Submittal of this safety basis document supports the referenced licensing action for the Blended Low-Enriched Uranium (BLEU) Project.

If you or your staff have any questions, require additional information, or wish to discuss this, please contact me, or Mr. Rik Droke, Licensing and Compliance Director at (423) 743-1741. Please reference our unique document identification number (21G-03-0074) in any correspondence concerning this letter.

NMSS01

Sincerely,

NUCLEAR FUEL SERVICES, INC.

B. Marie Moore
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WRS/smd
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cc:
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B M Moore to Dir., NMSS
March 13, 2003

21G-03-0074
GOV-01-55-04
ACF-03-0097

Attachment

Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building

Revision 2

Non-Proprietary Version

(77 pages to follow)

54T-03-0008
NCS-07-02
Revision 2

Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building

Framatome ANP/Nuclear Fuel Services, Inc.

March 2003

Revision 2

UNCLASSIFIED

RP Drake 03/13/03
Reviewed By Date

Nuclear Criticality Safety Evaluation for the BLEU Complex Uranyl Nitrate Building

Revision 2

R. D. Montgomery Criticality Safety Analyst	3/10/2003 Date
J. M. Deist Technical Reviewer	3/10/03 Date
C. J. Yeager Process Engineer	3/10/2003 Date
C. J. Yeager ISA Coordinator	3/10/2003 Date

Table of Contents

Index of Tables and Figures

Table 1 List of Acronyms

Acronym	Definition
BLEU	Blended Low Enriched Uranium
CA	Compressed Air
CCE	Configuration Controlled Equipment
CCS	Central Control System
CL	Critical Limit
CMF	Common Mode Failure
DCS	Distributive Control System
DIW	Deionized Water
DP	Differential Pressure
FL	Failure Limit
FHA	Fire Hazards Analysis
FRA-ANP	Framatome ANP, Inc
FRP	Fiberglass Reinforced Plastic
HAZOP	Hazard and Operability
HEU	High Enriched Uranium
ID	Inside Diameter
IM	Interspersed Moderator
IROFS	Item Relied On For Safety
ISA	Integrated Safety Analysis
LCO	Limiting Condition of Operation
LR-230	Liqui-Rad UN Shipping Container
NCS	Nuclear Criticality Safety
NCSE	Nuclear Criticality Safety Evaluation
NFS	Nuclear Fuel Services, Inc.
NUN	Natural Uranyl Nitrate
OCB	Oxide Conversion Building
OD	Outside Diameter
PHA	Process Hazards Analysis
ROL	Routine Operating Limit
SCALE	Standardized Computer Analyses for Licensing Evaluation
SNM	Special Nuclear Material
SOP	Standard Operating Procedure
SRE	Safety Related Equipment
SRS	Savannah River Site
UN	Uranyl Nitrate
UNB	Uranyl Nitrate Building

1.0 Introduction

The purpose of this Nuclear Criticality Safety Evaluation (NCSE) is to provide adequate criticality safety controls that will ensure the safe operation of the Uranyl Nitrate Building (UNB) for receiving and storing uranyl nitrate (UN) enriched to

This NCSE is applicable to UN solutions processed and stored in the UNB. With its very large UN storage capacity, the UNB approximates an infinite system. **Table 2** lists infinite system maximum k_{eff} (including 2σ) values for various concentrations of UN enriched to .

Criticality safety is demonstrated using a combination of passive engineered design features, active engineered design features, and administrative limits and controls to provide double contingency protection. Very conservative modeling assumptions are used throughout the NCSE. In many cases, more than two controls are present, providing defense-in-depth.

Table 2 Summary of Infinite UN System

$k_{eff} + 2\sigma$	~ Concentration (g U/l)

Section 2.0 describes the operation of the UNB. **Section 3.0** presents the hazard identification methodology and results.

Section 4.0 documents the accident analysis/evaluation performed. In **section 4.0**, potential process upsets that were identified are discussed. Methods and results of neutronics calculations are also documented in this section.

Section 5.0 presents the analysis assumptions. **Section 6.0** describes the passive and active engineered controls, as well as the administrative limits and controls. **Sections 7.0**, **8.0**, and **9.0** summarize the conclusions, area of applicability, and references, respectively.

Appendix A provides sample input files for the KENO-V.a and XSDRN calculations performed in support of this report. **Appendix B** contains copies of some references used for this analysis. **Appendix C** contains all supporting calculations and data.

2.0 Equipment, Process, and Material Descriptions

2.1 Equipment Description

The general arrangement, including elevation views, of the UNB is shown on drawing **ADU-01-701** (see **Appendix B**).

2.1.1 UN Receipt

2.1.2 UN Storage

2.1.3 NUN Storage

The current revision of this NCSE does not allow operation of the NUN equipment. Therefore, all NUN lines are disconnected and capped. Tags on disconnected or capped lines are posted with "Do not remove or reconnect without prior written approval from NCS", or other similar words. This prevents an inadvertent connection or a reconnection during construction of the OCB.

2.2 Process Description

2.2.1 UN Receipt

2.2.2 UN Storage

2.2.3 NUN Storage

As previously discussed, the current revision of this NCSE does not allow operation of the NUN equipment. Therefore, all NUN lines are disconnected and capped. Tags on disconnected or capped lines are posted with "Do not remove or reconnect without prior written approval from NCS", or other similar words. This prevents an inadvertent connection or a reconnection during construction of the OCB.

2.3 Material Description

UN transferred to and stored in the UNB has concentrations between , temperatures between , acid contents between , and is essentially clear and free of suspended solids. UN with these characteristics is compatible with the materials of construction used for handling UN in the UNB . See **section 2.1** for material descriptions of the various tanks in the UNB.

The floor of the UNB is constructed of concrete, .
The walls and roof of the UNB are metal construction.

3.0 Nuclear Criticality Hazard Identification

3.1 Hazard Identification Method

A hazard identification and analysis was performed for the UNB operation. This operation relies heavily on engineered controls to ensure that fissile solutions transferred to the UNB meet safety requirements. The engineered controls are further supported by administrative controls.

Identification of hazards and accident conditions that lead to undesirable consequences was accomplished by conducting a Process Hazards Analysis (PHA). A PHA was conducted for the UNB process system **(Reference 3)** with joint consideration of radiological, criticality, fire, and chemical hazards using the Hazard and Operability (HAZOP) technique as prescribed in **Reference 4.** A qualified team was utilized in the conduct of the PHA. Specifically included in the PHA team meetings were (1) a team leader trained in the methodology being used, (2) a person familiar with the design and operation of the process, and (3) one or more persons familiar with radiological, environmental, fire, and criticality safety.

A Fire Hazards Analysis (FHA) was performed and is documented in **Reference 10.** The use of water for fire fighting (including discharge of the fire sprinklers) will not interfere with the ability to prevent a criticality accident. Even in the unlikely event of a fire that causes a UN spill, addition of water will dilute the UN, moving the system into a safer condition with respect to NCS.

The PHA **(Reference 3)** did not identify any natural phenomena events, e.g., high wind, seismic event, flooding, that would result in a NCS hazard. Neither was any vehicle interaction accident identified that would result in a NCS hazard. These events may result in radiological and/or environmental concerns. It is left to the Integrated Safety Analysis (ISA) to address these concerns.

3.2 Hazard Identification Results

The events identified in the HAZOP analysis that could yield an accidental criticality as a consequence are summarized by number in **Table 3** and further analyzed in **section 4.1.**

Table 3 HAZOP Hazard Identification Matrix for UNB

Case # & PHA Initiating Event #	Deviation	Cause	Consequence	Comments
Node 1 – UN Transport Tank				

Table 3 HAZOP Hazard Identification Matrix for UNB

Case # & PHA Initiating Event #	Deviation	Cause	Consequence	Comments

Table 3 HAZOP Hazard Identification Matrix for UNB

Case # & PHA Initiating Event #	Deviation	Cause	Consequence	Comments

4.0 Nuclear Criticality Hazard Evaluation

4.1 Contingency Analysis for NCS Hazards

As discussed above, the HAZOP technique was used to identify process upsets that could potentially lead to a nuclear criticality scenario. These events are further examined here to determine that the double contingency principle is satisfied for credible process upsets. The double contingency principle may be stated as: "*The design of process equipment and systems to incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.*"

4.2 Calculations

Calculations are provided to demonstrate that the equipment in the UNB can be maintained in a subcritical state during normal operations and should anticipated upsets occur provided that the limits and controls **(section 6.0)** are observed.

4.2.1 Calculational Method

The calculations were performed using the KENO-V.a and XSDRN modules in the Standardized Computer Analyses for Licensing Evaluation (SCALE), Version 4.4a-PC **(Reference 1)**, to calculate the neutron multiplication factors, k_{eff} and k_{inf}, respectively. ENDF/B-V 238-group cross sections were used in the evaluation. SCALE 4.4a-PC and associated modules using ENDF/B-V 238-group cross sections were validated on FRA-ANP computer PIN #21487.54 and #21487.62 in **Reference 2**. The calculations in this NCSE are bounded by the **Reference 2** validation report. Based on the results of the validation report, a system is considered subcritical if $k_{eff}+2\sigma$ is less than 0.97. Example input decks are contained in **Appendix A** of this NCSE.

4.2.2 Description of Model

The following three sets of models were prepared and analyzed in this report:

- Infinite UN system
- Infinite UN slab
- UNB interaction model

Table 4 Summary of UNB Tank Dimensions

Tank #	Diameter (in)		Height (in)	
	Actual	Model	Actual	Model

4.2.3 Results

Infinite UN System

Figure 2 Infinite UN System with Various Acid Contents (region of interest is expanded)

Description	Concentration Value	Associated Concentration Value k_{eff}	Applied Measurement Uncertainty	Applied Code Bias k_{eff}	Applied Code Bias Uncertainty k_{eff}	Applied k_{eff} Margin	Corrected or Applied Concentration Value	[illegible]

5.0 Analysis Assumptions

6.0 Passive and Active Engineered Controls and Administrative Limits and Controls

Criticality safety of the UNB is provided by a combination of passive engineered controls, active engineered controls, and administrative limits on activities. Each control relied upon in the double contingency analysis is discussed in this section.

6.1 Safety Related Equipment (SRE)

If equipment or a design feature (1) is an active engineered control or (2) can change (degrade) with time, then that equipment or design feature is specified as SRE. As such, it is placed in the SRE program, with specific surveillance, preventative maintenance, and functional testing requirements. The NCSE may specify SRE requirements for a particular piece of equipment or design feature, or may leave that determination to process engineering.

6.2 Configuration Controlled Equipment (CCE)

Equipment and/or a design feature is defined as CCE if it meets one of the following criteria: (1) it can be demonstrated that the equipment will not change with time, (2) a criticality is not possible even if the equipment does change with time, or (3) the equipment is supplemented by other controls to form one leg of double contingency.

6.3 Administrative Limits and Controls

This section lists the limits and controls required to provide double contingency protection against an accidental criticality. These controls will be identified in operating procedures and/or station limit postings.

7.0 Conclusion

A criticality analysis of operations in the UNB of the NFS / FRA-ANP BLEU Complex has been completed. Criticality safety is demonstrated using a combination of passive engineered design features, active engineered design features, and administrative limits and controls to provide double contingency protection. Conservative modeling assumptions are used throughout the NCSE. In many cases, more than two controls are present to provide defense-in-depth.

8.0 Area of Applicability

9.0 References

1) *SCALE (CCC-545): A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation*, NUREG/CR-0200, Rev. 6 (ORNL/NUREG/CSD-2/R6), Volumes I, II, and III, March 2000.

2) *Validation of SCALE 4.4a-PC for Homogeneous Uranium Systems with Enrichments between 0.72 and 10.0 wt% ^{235}U Using the 238-Group ENDF/B-V Cross Section Library*, 54T-03-0009, Revision 1, Framatome ANP, Inc. and Nuclear Fuel Services, Inc., February 2003.

3) *Hazards Analysis – BLEU Uranyl Nitrate Building (UNB)*, 54T-02-006, NCS-07-02, Framatome ANP, Inc.

4) Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples, Center for Chemical Process Safety of the American Institute of Chemical Engineers, 1992.

5) Certificate of Compliance No. 9291, "Liqui-Rad (LR) Transport Unit Package for the Transportation of Type B Fissile Uranyl Nitrate Solutions, US NRC.

6) R. C. Kispert, J. H. Cavendish, N. R. Leist, and G. P. Miller, "Crystallization Characteristics of Acidic Uranyl Nitrate Solutions," National Lead Company of Ohio, Revised July 9, 1968.

7) K. D. Barlow, "UNH Evaporation Calculations," KDB:01:001, Framatome ANP, Inc., December 3, 2001.

8) C. F. Holman, "Uranyl Nitrate Building (UNB) Solution Freezing Calculation," CFH:02:002, Framatome ANP, Inc., March 5, 2002.

9) ARH-600, Criticality Handbook, Atlantic Richfield Hanford Company.

10) *Fire Hazards Analysis – BLEU Uranyl Nitrate Building (UNB)*, Materials Design Evaluation, August 2002.

11) C. F. Holman, "Uranyl Nitrate Storage Tank Fire Evaporation Calculation," CFH:02:003, Framatome ANP, Inc., August 9, 2002.

12) C. F. Holman, "Supplemental Calculations for the UNB NCSE," CFH:03:001, Framatome ANP, Inc., February 24, 2003.

13) C. E. Athon, "Uranium Density in Uranium Peroxide Precipitate," CEA-97-012, Nuclear Fuel Services, Inc., January 16, 1997.

APPENDIX A

Calculation Input Decks

APPENDIX B

Supporting References

APPENDIX C

Supporting Calculations and Data

File ID	Concentration (g U/l)	[illegible]	[illegible]	[illegible]

File ID	Concentration (g U/l)	[illegible]	[illegible]	[illegible]

[illegible]	Concentration (gU/l)	[illegible]	[illegible]	[illegible]

File ID	Concentration (gU/l)	[illegible]	[illegible]	[illegible]

File ID	Concentration (g U/l)	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Enrichment (wt% ^{235}U)	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Enrichment (wt% ^{235}U)	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Concentration (g/l)	[illegible]	σ	[illegible]

File ID	Concentration (g/l)	[illegible]	[illegible]	[illegible]

File ID	Concentration (g/l)	Slab Half Thickness (cm)	Slab Thickness (cm)	Slab Thickness (in)

File ID	Concentration (g U/l)	Slab Half Thickness (cm)	Slab Thickness (cm)	Slab Thickness (in)

File ID	Concentration (g U/l)	Slab Half Thickness (cm)	Slab Thickness (cm)	Slab Thickness (in)

File ID	Concentration (gU/l)	Slab Unit Thickness (cm)	Slab Thickness (cm)	Slab Thickness (in)

File ID	Vol% M	[illegible]	[illegible]	[illegible]

File ID	Concentration (gU/l) in Bash [illegible]	[illegible]	[illegible]	[illegible]

File ID	Depth (in) of Concentrated UN	[illegible]	[illegible]	[illegible]

File ID	Depth (in) of Concentrated UN	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Depth (in) of Concentrated UN	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Depth (in) of Concentrated UN	k_{eff}	σ	$k_{eff}+2\sigma$

File ID	Depth (in) of Concentrated UN	k_{eff}	σ	$k_{eff}+2\sigma$

File ID (No Bias ID Data)	[illegible]	σ	$k + 2\sigma$	File ID (Bias ID Used)	$k + 2\sigma$	Δk