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Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
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Louisiana Energy Services, LLC
National Enrichment Facility
NRC Docket No. 70-3103

Subject: National Enrichment Facility revision to the Nuclear Criticality Safety Validation Report (MONK 8A Validation and Verification)

References: SNM-2010, Louisiana Energy Services Material License

Louisiana Energy Services Material License, Condition 25 states:

"If there are any revisions to the nuclear criticality safety validation report, then the licensee shall provide a letter to NRC describing the changes and shall provide the revised validation report upon request. The licensee may not implement the changes in the revised validation report until NRC approves the changes".

Louisiana Energy Services hereby requests NRC's approval of Revision 4 to the Nuclear Criticality Safety Validation Report.

Enclosure 1 provides the background, proposed changes, and basis for the revised Nuclear Criticality Safety Validation Report. Enclosure 2 provides the marked up pages of the revised Nuclear Criticality Safety Validation Report.

NMSS01

LES requests approval of this revision of the Nuclear Criticality Safety Validation Report by September 30, 2008. LES appreciates the efforts of the NRC staff in supporting the review and approval of this important amendment in a timely manner. If you have any questions about this request please contact Stephen Cowne, Quality and Regulatory Affairs Director at 575-394-4646.

Respectfully,

Gregory OD Smith
Chief Operating Officer and Chief Nuclear Officer

Enclosure 1: Background, Proposed Change, Basis for Change, Safety Significance, and Environmental Considerations
Enclosure 2: Marked Up Pages for Nuclear Criticality Safety Validation Report, Revision 4

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Enclosure 1
Background, Proposed Change, Basis for Change, Safety Significance, and Environmental Considerations

Background

Criticality calculations for the National Enrichment Facility (NEF) Integrated Safety Analyses (ISA) were developed by AREVA NP, Inc. using the MONK 8A, Monte Carlo computer code. This code was validated by AREVA as documented in the MONK 8A Validation and Verification (Nuclear Criticality Safety Validation Report). Future criticality calculations will be performed by LES, using the MONK 8A, Monte Carlo computer code. In order to do this, the Nuclear Criticality Safety Validation Report requires modification allowing the program to be used on an NEF computer (PC).

Proposed Change

1. A description of the changes for Revision 4 has been added to the Abstract section.

2. Section 1.2, Scope has been changed to read: "The scope of this report is limited to the validation of the MONK8A Monte Carlo computer code and JEF 2.2 data library and the verification of criticality calculations performed for *and by* the NEF."

3. Section 2, Calcuational Method – Replace "The MONK 8A code package is installed and verified on the Framatome-ANP Personal Computer (FANP PC) hardware platform." with the MONK 8A code package has been installed and verified on the Framatome-ANP Personal Computer (FANP PC), Enrichment Technology Corporation Personal Computer (ETC PC), and National Enrichment Facility Personal Computer (NEF PC) hardware platforms."

4. Section 2, Table 2-1 – Corrected library name.

5. Section 3, Criticality Code Validation Methodology, states (in part):

   "A label is placed on the FANP PC indicating that it is a computer used for QA condition for Nuclear Safety related activities and that the configuration cannot be changed without authorization."

   Since a label will also be applied to the NEF PC(s), the specific reference to the "FANP" PC has been deleted.

6. Section7.1, Benchmark Results Compared to Serco Results – Replace FANP PC" with "computer hardware".

7. Four (4) sections of the Nuclear Criticality Safety Validation Report indicate that the MONK 8A code package was installed on AREVA computer "FANP PC" which is owned and operated by AREVA. These sections have been modified to add: ",ETC and NEF PCs". The affected sections are:

- Section 2, Calculational Method (2nd paragraph)
- Section 3, Criticality Code Validation Methodology (2nd paragraph)
- Section 7, Validation
- Section 7.1, Benchmark Results Compared to Serco Results (last paragraph)

Basis for the Change

AREVA was contracted to provide LES with an ISA to obtain the Material License. Future changes to the ISA will be conducted by LES. The MONK 8A software will continue to be used for criticality calculations. The MONK 8A program has been validated and approved for use on an NEF PC for criticality calculations using LES Procedure IT-3-1000-02, Software Qualification. It has been installed on an NEF PC and test cases were executed on the NEF PC. The results of those test cases replicated the validation cases used in the previous revision of the Nuclear Criticality Safety Validation Report providing assurance that the software will function properly on the NEF PC(s).

Safety Significance

Based on the successful LES validation and approval of the MONK 8A software package and the acceptable results of the test cases run on the NEF PC, there is no safety significance associated with this revision of the Nuclear Criticality Safety Validation Report.

Environmental Considerations

There are no significant environmental impacts associated with the changes proposed in this revision of the Nuclear Criticality Safety Validation Report. The proposed changes do not meet the criteria specified in 10CFR 51.60(b)(2) since they do not involve a significant expansion of the site, a significant change in the types of effluents, a significant increase in the amounts of effluents, a significant increase in individual or cumulative occupational radiation exposure, or a significant increase in the potential for or consequences from radiological accidents. Consequently, a separate supplement to the Environmental Report is not being submitted.

Enclosure 2
Marked Up Pages for Nuclear Criticality Safety Validation Report, Revision 4

ABSTRACT

The objective of this report is the validation of the MONK 8A, Monte Carlo computer code package. The validated MONK 8A code is then used to verify the criticality calculations performed by Urenco for the National Enrichment Facility.

MONK 8A was validated against a set of 93 benchmark critical experiments. The average of the validation runs was 1.0017 ± 0.0045. A subset of these experiments was selected to compare against the MONK 8A benchmark performed by the computer code vendor for the purpose of verification. The average of the verification runs was 1.0001 ± 0.0005. This was in good agreement with the average of the corresponding MONK 8A benchmarks of 1.0000 ± 0.0006 performed by the computer code vendor. Also, thirty Urenco criticality calculations were selected for verification. The average of the Urenco results documented for the thirty cases used for comparison in this report is 0.8764. The average of the verification runs is 0.8744 which is in good agreement with the Urenco results.

Revision 1 of this report expanded and reformatted the report to add more detail to ensure that the report addressed all of the commitments made in Chapter 5 of the National Enrichment Facility Safety Analysis Report (Reference 11).

Two specific items included in the report are the description of the Area of Applicability (AOA) and determination of the Upper Safety Limit (USL).

Revision 2 of this report removed the High Enriched Uranium benchmark critical experiments from the validation and added two additional Low Enriched Uranium critical experiments and one additional Intermediate Enriched Uranium critical experiment to the validation. This approach is more representative of the enrichments associated with the National Enrichment Facility and still maintains the range of the Hydrogen/Uranium ratio inside the area of applicability.

Revision 3 of this report corrected errors that were discovered during the review process. None of the corrections altered the USL results reported in Revision 2.

- The H/U ratios for the experiments that involved more than one composition in the fuel region for a given case have been corrected. Specifically, experiment 42, cases 13 through 18, and all of the cases for experiment 69 are revised.
- The mean log energy of neutron causing fission data for experiment 42, cases 13 through 18 have been revised.
- Attachment 1C was revised to correct an editing error involving the mean log energy of neutron causing fission values.
- The average and standard deviation calculated for the benchmark were added to Section 6.1.
- The weighted average k_{eff} in Section 6.1 was corrected to 1.0009.
- Other minor editorial changes were made.

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Revision 4 of this report consists of editorial changes to include the use of MONK 8A on the ETC and NEF computer systems. The USL was not altered.

1 Introduction

1.1 Purpose

The purpose of this report is to validate the criticality codes and determine the Upper Safety Limit (USL) to be used for performing nuclear criticality safety calculations and analyses of the National Enrichment Facility (NEF).

[redacted]
and by the NEF.

1.2 Scope

The scope of this report is limited to the validation of the MONK8A Monte Carlo computer code and JEF 2.2 data library and the verification of criticality calculations performed for ~~the NEF~~ 2.

1.3 Applicability

The area of applicability (AOA) is identified to cover the entire range of activities in the plant. Any accumulation of uranium is taken to be in the form of a uranyl fluoride / water mixture.

1.4 Background

1.4.1 Overall NEF Design

The plant is designed to separate a feed stream containing the naturally occurring proportions of uranium isotopes into a product stream - enriched in the uranium-235 (^{235}U) isotope and a tails stream - depleted in the ^{235}U isotope. The NEF will be constructed on a LES site and licensed by the U.S. Nuclear Regulatory Commission (NRC) under Title 10 Code of Federal Regulations (CFR) Part 70. The facility is designed to applicable U.S. codes and standards and operated by LES.

1.4.2 Regulatory Requirements

10 CFR 70.61 requires that "under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety." In order to comply with this requirement, NEF Safety Analysis Report (SAR) Section 5.2.1.5 (Reference 11) requires a validation report that (1) demonstrates the adequacy of the margin of subcriticality for safety by assuring that the margin is large compared to the uncertainty in the calculated value of k_{eff}, (2) determines the areas of applicability (AOAs) and use of the code within the AOA such that calculations of k_{eff} are based on a set of variables whose values lie in a range for which the methodology used to determine k_{eff} has been validated, and (3) includes justification for extending the AOA by using trends in the bias, i.e., demonstrates that trends in the bias support the extension of the methodology to areas outside the AOAs.

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The MONK 8A code package has been installed and verified on the Framatome-ANP Personal Computer (FANP PC), Enrichment Technology Corporation Personal Computer (ETC PC), and National Enrichment Facility Personal Computer (NEF PC) hardware platforms.

2 Calculational Met

The MONK 8A code package is the computational code used for NEF criticality analyses. The code package is available through Serco Assurance. ~~The MONK 8A code package is installed and verified on the Framatome-ANP Personal Computer (FANP PC) hardware platform.~~ 3

MONK 8A is a powerful Monte Carlo tool for nuclear criticality safety analysis. The advanced geometry modeling capability and detailed continuous energy collision modeling treatments provide realistic three-dimensional models for an accurate simulation of neutronics behavior to provide the best estimate neutron multiplication factor, k-effective. Complex configurations can be simply modeled and verified. Additionally, Monk 8A has demonstrable accuracy over a wide range of applications. The NEF criticality analyses are performed using MONK 8A and the JEF 2.2 data library. Specifically, the data library files listed in Table 2-1 were us 8A validation and verification runs. These files were provide by the compute Serco, and are stored on the FANP PC. The MATCDB data file is used for specification. This datafile is a databa 4 of composition of standard materia datafile is used for determining cross sections. The datafile is a point energ The THERM datafile is also used for determining cross sections. This datafile is the thermal library file that must be used with DICE when hydrogen bound in water or polythene is present.

,ETC PC(s), and NEF PC(s).

Aside from the use of these data libraries no other code options need to be chosen. The rest of the input corresponds to building the proper geometry and material compositions to be used in the calculations. The input for the geometry and material composition is straight forward. Attachment 1A includes one input file for each of the 11 experiments.

Table 2-1 Data Libraries for Validation and Verification

Library Types	Library Names
MATCDB:	~~monk_matdbv2.dat~~
DICE:	dice96j2v5.dat 4
THERM:	therm96j2v2.dat

monk_matdbv2d.dat

3 Criticality Code Validation Methodology

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,ETC PC(s), and NEF PC(s)..

In order to establish that a system or process will be subcritical under all r abnormal conditions, it is necessary to establish acceptable subcritical lim and then show the proposed operation will not exceed those values.

The validation process involves three primary steps. The first step involves the procurement, installation, and verification of the criticality software on a specific computer platform. For the NEF, the MONK 8A code package was procured, installed and verified on the FANP PC hardware platform. A label is placed on the FANP PC indicating that it is a computer u 7 for QA condition for Nuclear Safety related activities and that the configuration cannot be changed without authorization. This computer is a standalone computer where no automatic updates are allowed to occur to the operating system. This process ensures that the computer configuration

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,ETC PC(s), and NEF PC(s).

7 Verification

NUREG 1520 requires a description of the verification process and results. In addition, NUREG 1520 requires a description of mathematical testing. In this report the verification and mathematical testing process is performed in three steps. The first step is to compare the results obtained in the AREVA benchmark to the computer code vendor, Serco, published results to show that MONK 8A was correctly installed and executed on the FANP PC. The second step is show that the results are repeatable if run at different times. This step is needed because MONK 8A uses the date time stamp to select a random seed value. Therefore, this step ensures that the results are similar if a different seed value is used. The final step is to repeat a subset of the MONK 8A criticality analysis cases run by Urenco. Urenco ran an extensive set of MONK 8A criticality calculations in support of their existing facilities and NEF. This step ensures that the cases run by Urenco are similar to the AREVA benchmark cases.

7.1 Benchmark Results Compared to Serco Results

The MONK 8A computer code vendor, Serco, provided a set of benchmarks identical to the benchmarks performed in this study to assure that the computer code ha
computer hardware
installed correctly on the FANP PC and that the mathematical models are wo correctly. Table 7-1 shows the results of the MONK 8A benchmark calculate computer code vendor and from the AREVA verification runs. Table 7-1 has following definitions.

- "Serco Benchmark" is the k_{eff} (Reference 6) values from the Serco benchmark report.
- "AREVA Validation" are the k_{eff} values from the validation runs.
- "Count" is the total number of experiments.
- "Average" is the average of all the Serco benchmark and AREVA validation k_{eff} values calculated using the Excel AVERAGE function.
- "Standard Deviation" is the standard deviation of the k_{eff} values from the Serco benchmark and AREVA validation. The standard deviation used the Excel STDEV function which uses the equation:

$$\sigma = \sqrt{\frac{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)}};$$

where $x_i = k_{eff}$ of each experiment, n= number of experiments (36).

- "Standard Error" is the Standard Error of Measurement (Reference 7) of the k_{eff} values from the Serco benchmark and AREVA validation and uses the equation.

$$\sigma_M = \frac{\sigma}{\sqrt{n}}.$$

Because the random number generator seed values were based on the MONK 8A default feature, the date and time of execution, the results of each experiment would not be expected to exactly match the Serco benchmark results. The average of the Serco benchmark cases, for the 8 cases used in this verification is 1.0000 ± 0.0006

(Reference 6). The average of the AREVA verification runs was 1.0001 ± 0.0005 as shown in Table 7-1. The agreement between the benchmark values and the validation runs is very good with the difference being attributed to the use of different seed values. This comparison shows that the computer code was installed on the FANP PC correctly.

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,ETC PC(s), and NEF PC(s).

7.2 Repeatability

As mentioned earlier, a fundamental feature [redacted] codes is the requirement of a random number to initiate the calculation. By default, MONK 8A utilizes the date and time of execution to derive the seed values for each case. It is of interest to evaluate the effect of the random number seed values for MONK 8A. Therefore, one validation case is chosen for a brief sensitivity study of this effect. The first case of experiment 43 listed in Table 7-1 was run on different dates and times to test the repeatability and reliability of MONK 8A. The results are summarized in Table 7-2.

The average k_{eff} of the six runs was 0.9976 with a standard deviation of 0.0011. Since the convergence criterion for the runs was a standard deviation of 0.0010; this demonstrates that MONK 8A calculates consistent results.

7.3 Verification of Urenco MONK 8A Cases

Urenco ran an extensive set of MONK 8A criticality calculations in support of their existing facilities and NEF. Thirty representative cases were selected for verification of the MONK 8A criticality analysis run by Urenco. As described in the validation section, the default seed values for the random number generator are used to make this verification independent of Urenco.

It is of interest to verify the reproducibility of the Monte Carlo solution. Therefore, the original random seed values were used in the first six cases in Table 7-3 to track the reproducibility of MONK 8A on the QA controlled computer. These six cases with the original seed values produced identical results to the Urenco cases.

The first six cases in Table 7-3 were also repeated with the default seed values. The results of all thirty cases chosen for verification are shown in Table 7-3. The average of the Urenco results for the thirty cases used in this report is 0.8764. The average of the verification runs is 0.8744 as shown on Table 7-3. The documented values and the verification runs are in good agreement.