July 30, 2008

To:	J. N. McKamy	Manager, Nuclear Criticality Safety Program
From:	J. A. Morman	Chair, Criticality Safety Support Group
Subject:	**Response to CSSG Tasking 2008-04**	

The Criticality Safety Support Group (CSSG) was tasked by the Nuclear Criticality Safety Program (NCSP) Manager to address a question posed by a staff member of the Department of Energy (DOE) Savannah River Operations Office. The complete tasking statement is included as Attachment 1 to this report.

The specific issue in the tasking is the intended meaning and proper usage of the "margin in the k-eff" in Section 4.3.3 of ANS-8.1. The section is quoted below.

> *The uncertainty in the bias shall contain allowances for uncertainties in the experimental conditions, for lack of accuracy and precision of the calculational method, and for extension of the area (or areas) of applicability. After allowances are made for the accuracy and precision of the method and for the bias and uncertainty, a margin in the k-eff or other correlation parameter* ***shall*** *be applied that is sufficiently large to ensure that conditions (calculated by the method to be subcritical by this margin) will actually be subcritical. Like the bias and its uncertainty, this margin may vary with composition and other variables.*

It is noted that an official interpretation of any requirement in an ANSI/ANS-8 Standard can only come from the working group for that standard, and thus the following comments only provide an expression of how the CSSG would interpret the requirements of the above section of ANS-8.1 relative to its application in probabilistic risk analysis (PRA) studies.

The additional margin, generally implemented as a delta-k adjustment to the calculational k_{eff} result, is utilized to assure that the calculated k-eff value is subcritical. This margin is also sometimes referred to as the "margin of subcriticality". However, it is clear that the application of this margin may not be appropriate in all cases. In what follows, this margin is identified as "margin in k_{eff}."

The establishment of a safety basis for fissile material operations frequently requires the setting of process limits and these are commonly developed from calculations of the k_{eff} of various fissile material configurations. The object is to determine if a fissile material configuration is safely "subcritical" under normal and credible abnormal conditions. To assure that the limits and controls provide the necessary safety, an additional delta-k is normally applied, in addition to the evaluated bias and uncertainty, to the calculated values. From the bracketed statement in the second sentence of Section 4.3.3, the use of the margin of subcriticality applies to calculations meant to assure the fissile configuration would be subcritical.

Other applications of k_{eff} calculations include those to determine the actual critical value such as in benchmark studies or in finding the actual failure limit for an upset condition. In these cases, an additional margin in k_{eff} may not be appropriate as it would distort the meaning of the benchmark and/or the physical reality. The application of an additional margin to k_{eff} calculations in support of PRA studies would depend on the purpose of the study. If the object of the PRA was to determine actual probabilities of a critical event, the use of this additional margin in the determination of actual critical states would distort the study and limit its usefulness. Should the application of the PRA be to support the determination of operational or safety limits associated with maintaining subcriticality, the application of the additional margin in k_{eff} would be appropriate. Hence, the appropriate selection of this additional margin in k_{eff} should be dependent upon the intended usage of the calculated k-eff value (e.g., non-zero additional margin for cases in which a configuration is to be demonstrated to be safely subcritical, zero additional margin for cases in which a critical configuration is to be determined) and can make the two proposed approaches consistent.

Attachment 1

CSSG TASKING 2008-04
Date Issued: June 30, 2008

Task Title:

Definition of critical in terms of calculated reactivity for use in probabilistic risk analysis.

Task Statement:

Recently, an issue has surfaced at the Savannah River Site regarding the proper use of margin of subcriticality in conjunction with Probabilistic Risk Analysis (PRA). The purpose of a PRA is to determine the frequency that a criticality would occur for a given set of circumstances. A fault tree is developed with those events that in conjunction would lead to a critical configuration – the individual probabilities of those events are then combined mathematically to determine the overall frequency that the string required to reach criticality may be achieved. This process is used in some facilities to determine if criticality accident alarms are required. The critical configuration as well as most event sequences are determined by the criticality group and then fed to the risk analysis group for application of the PRA methodology to sequence the events and to assign probabilities. At question is the proper reactivity of the configuration to define as "critical". The two trains of thought are:

1. ANSI standards require that an arbitrary margin be provided that assure configurations calculated to be subcritical are truly subcritical (e.g., see ANSI/ANS-8.1, Paragraph 4.3.3.) Therefore the determination of when a system is critical is that point above which it can no longer be assured that it is safely subcritical (this is the same value used in typical NCSEs to set Criticality Safety Limits and is equivalent to 1 + bias – bias uncertainty – margin of subcriticality).

2. Since PRA is a mathematical tool to determine the frequency of an event (criticality), the proper reactivity to determine if an event is critical is 1+ bias – bias uncertainty without the application of a subcritical margin (you are not trying to determine if a configuration is safety subcritical, but instead if a configuration is (or could be) critical). The value of 1 + bias is the best estimate of a critical configuration as defined by the code. The application of the bias uncertainty to that value provides a small amount of margin for uncertainties in cross sections, experiments, etc.

To date, this issue has not been resolved on-site. The Department of Energy - Savannah River Operations Office (DOE-SR), Washington Savannah River Company (WSRC) and Washington Safety Management Solutions (WSMS) have agreed to seek additional external guidance. Thus, the CSSG is being requested to provide guidance on the subject. For further information on the specific use of the methodology or further background on the issue, please contact either Glenn Christenbury (DOE-SR) at 803.208.3737 or Fitz Trumble (WSMS) at 803.221.1152.

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Period of Performance:

The site has adopted a conservative philosophy on a forward fit basis until this issue is resolved. However, it has been decided that no explicit effort will be made to revise any existing analyses until the issue is resolved. Accordingly, while there is no immediate impact to ongoing operations, a prompt response would be appreciated.

Resources:

NCSP CSSG FY08 funding will cover this effort. However, no travel is expected to be necessary to support this request. Mr. Trumble has offered to abstain from this activity due to his involvement in this issue. It is requested that his request be honored.

Task Deliverables:

A formal written report under the signature of the CSSG Chair should be provided to the NCSP Manager electronically. The NCSP Manager will review and forward to Glenn Christenbury, DOE-SR Criticality Safety Program Manager.

Task Due:

July 31, 2008
