June 7, 2005

MEMORANDUM TO: Robert C. Pierson, Director
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

THRU: Melanie A. Galloway, Chief **/RA/**
Technical Support Group
Division of Fuel Cycle Safety
and Safeguards, NMSS

FROM: Harry D. Felsher, Nuclear Process Engineer **/RA/**
Technical Support Group
Division of Fuel Cycle Safety
and Safeguards, NMSS

SUBJECT: SUMMARY OF MAY 20, 2005, WORKSHOP ON DRAFT DIVISION OF FUEL SAFETY AND SAFEGUARDS-INTERIM STAFF GUIDANCE-10

On May 20, 2005, U.S. Nuclear Regulatory Commission (NRC) staff met with members of industry and the public in the Workshop on draft Division of Fuel Cycle Safety and Safeguards (FCSS)-Interim Staff Guidance (ISG)-10, entitled, "Justification for Minimum Margin of Subcriticality for Safety." The purpose of this workshop was to for NRC technical staff to have discussions regarding the purpose and intent of draft FCSS-ISG-10 with, and obtain comments from, industry, stakeholders, and interested members of the public. The summary of the workshop is attached and includes the list of attendees, draft FCSS-ISG-10, workshop agenda, and NRC presentation slides/Industry handout. This summary contains no proprietary or classified information.

Attachment: Summary of Workshop on Draft FCSS-ISG-10

cc: Meeting Attendees (external to NRC)

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Attachment: Summary of Workshop on Draft FCSS-ISG-10
cc: Meeting Attendees (external to NRC)

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Summary of the Workshop on Draft
Division of Fuel Cycle Safety and Safeguards-Interim Staff Guidance-10,
"Justification for Minimum Margin of Subcriticiality for Safety"

**Date:** May 20, 2005

**Place:** NRC Auditorium, Rockville, MD

**Attendees:** See Enclosure 1

**Purpose:**

The purpose of this workshop was for NRC technical staff to have discussions regarding the purpose and intent of draft Division of Fuel Cycle Safety and Safeguards (FCSS)-Interim Staff Guidance (ISG) -10 with, and obtain comments from industry and interested members of the public. This workshop was a Category 3 NRC Meeting with the public invited to participate during the discussion and at designated points on the agenda. The draft of FCSS-ISG-10 that was provided for public comment is contained in Enclosure 2. The workshop agenda is contained in Enclosure 3. The NRC slide presentations and the Industry handout are contained in Enclosure 4.

**Discussion:**

**Section 1 - Opening, Context, Industry Key Issues, and General Comments Received:**

Welcome/Introduction/Opening Remarks:

In welcoming remarks, the NRC thanked everyone for attending, encouraged attendees to participate in discussions, discussed the objective, goal, topic, agenda, ground rules, and initiated a "parking lot" for new issues. The objective of the workshop was for NRC and Industry to understand each others' concerns and comments. The goal after the workshop will be for NRC to revise draft FCSS-ISG-10 to ensure that the intent and guidance is clear. In addition, NRC staff provided a history of 10 CFR Part 70 activities and previous workshops related to the ISGs. In its opening remarks, Industry noted that it appreciated the opportunity for open communication, it appreciated NRC's effort to act as one voice, and it also attempts to act as one voice.

At the July 2004 Integrated Safety Analysis (ISA) Workshop, the need for FCSS-ISG-10 was first identified. At the February 22, 2005, ISA Workshop, the need for a workshop specifically on FCSS-ISG-10 was identified and both NRC and Industry agreed to hold the workshop sometime in May 2005. The agenda for the FCSS-ISG-10 Workshop determined by NRC and Industry was the following: (1) NRC presentation on the context and intent of draft FCSS-ISG-10; (2) Industry presentation on key issues; (3) NRC staff and Industry discussion on Industry key issues; (4) for each section of draft FCSS-ISG-10, NRC presentation, followed by Industry discussion, then followed by a general discussion of the topic; (5) separate NRC staff and Industry caucuses; and (6) summary. NRC defined ground rules were: (1) use a facilitator and the discussion thread format (i.e., continue with the discussion topic until it is completed); (2) focus is on draft FCSS-ISG-10 and fuel cycle facilities; (3) comments from

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anyone in the audience are acceptable at any time; (4) this is an open public meeting, so no proprietary or classified information should be provided; (5) issues identified during the workshop that need further action are placed in a "parking lot" of follow-up items. All attendees introduced themselves, were requested to sign the attendees list, and were requested to complete a meeting comment form for feedback on workshop conduct and focus.

<u>NRC Presentation Context/Intent of Draft FCSS-ISG-10:</u>

NRC presented information regarding the context/intent of draft FCSS-ISG-10 (see Enclosure 4a). The topics were: (1) motivation for draft FCSS-ISG-10, (2) purpose of draft FCSS-ISG-10, (3) philosophy/intent of draft FCSS-ISG-10, (4) approach of draft FCSS-ISG-10, and (5) five main types of written comments that NRC received on draft FCSS-ISG-10 (not in order of importance). NRC was holding this workshop to solicit and clarify comments received in order to finalize the guidance.

Members of the Public and Industry understood the NRC's context/intent of draft FCSS-ISG-10 from the NRC presentation, but they stated that the document itself is unclear and does not meet those objectives. Industry requested an example, outside of the application for the mixed-oxide fuel fabrication facility, where there was Industry interest in reducing margin. The BWX Technologies (BWXT) Industry representative responded that an example was the BWXT site, which requested a smaller margin for a specific application and that the information in draft FCSS-ISG-10 was extremely helpful in understanding what was needed for the amendment.

<u>Industry Presentation on Key Issues:</u>

Industry presented information regarding the Industry key issues on draft FCSS-ISG-10 (see Enclosure 4b). The issues in order of importance were: (1) potential impacts on currently approved operations associated with the 0.10 margin (high enriched uranium (HEU)/plutonium(Pu)) and 0.05 margin (low enriched uranium (LEU)) because they are too prescriptive and not aligned with current licensee margins; (2) too much emphasis is placed on validation and benchmark experiments, which is not risk-informed; and (3) NRC should ensure that draft FCSS-ISG-10 is consistent with current American Nuclear Society (ANS) standards, including terminology and approach, and NRC may need to revise draft FCSS-ISG-10 after the proposed ANS-8.24 Validation standard is issued.

Specifically on issue (1), Industry indicated that:

- Few, if any, of the current licensees have those margins;
- Industry sees those margins as being new regulatory requirements; and
- NRC needs to change the text language to clarify the ISG.

NRC clarified that this ISG attempted to convey a risk-informed approach by indicating that a margin of 0.05 for LEU facilities and 0.10 for HEU/Pu facilities would necessitate a less detailed validation/benchmark review. As margins are reduced from these values, a more detailed review is needed. NRC emphasized that it is acceptable for a licensee to have other margins to meet the regulatory requirements and that there are no new regulatory requirements.

Industry was concerned that during license renewal, the licensees would have to justify not meeting the margins in draft FCSS-ISG-10, or will be forced to shut down. If they have to use the margins or the margins change over time, then operations will have to be changed because of new interpretations and guidance. Therefore, in Industry's view, it could have a large economic impact on operations.

NRC understood Industry's concern, but noted the following:

- License renewal has the same regulatory requirements as an initial application;
- As always, a licensee needs to conform to regulatory requirements;
- NRC takes a risk-informed approach during license renewal (e.g., if NRC technical basis for approval in the safety evaluation report (SER) is well-documented and nothing has changed, then review will be less and review will focus on changes since the last renewal);
- However, NRC has acknowledged in this forum and other forums that it has not provided in previous SERs a well-documented technical basis for approving the margin during license renewal, and thus, this will be part of the license renewal process;
- NRC agrees that the specific margin in $k_{eff}$ is only a portion of the demonstration of subcriticality safety and that operating parameters play a part;
- Should a licensee choose to demonstrate subcriticality by relying in whole or in part on controls on operating parameters, NRC is willing to work with that licensee to appropriately characterize that approach in the license application;
- Backfit does not apply to licensing actions (e.g., license renewal and amendments); and
- NRC expects that licensees have adequate justification for the margins to meet regulatory requirements and commitments to the ANS standards. During license renewal, NRC will seek and review this information and provide a well-documented technical basis for subcriticality in the SER; if this is not true, then the question to ask licensees is "what is lacking to meet the subcritical requirements?"

Industry requested that NRC state in draft FCSS-ISG-10 that current license margins are acceptable without further review. The Industry view is that it should be apparent that current licensees have already gone through the process. NRC indicated this would not be appropriate because it is not clear that NRC has previously documented in SERs that licensees have provided sufficient technical justification for the margins.

Industry identified that a current licensee has a commitment to a certain margin as well as to ANS-8.1 and, therefore, a current licensee has to have the documentation at the site. In addition, through previous license renewals, amendments, and inspection, this margin has been reviewed by NRC. Also, NRC has come to the site in the past and can do so in the future to review the documentation.

Industry recommended deleting the references to 0.05 and 0.10 margins in draft FCSS-ISG-10 and replacing them with the 0.02 minimum margin from ANS-8.1. This gives a minimum number that is acceptable and if a licensee wants to go lower than technical justification is needed. NRC indicated that this would not be appropriate because: (1) these .05 and .10 margin numbers are the starting point of the NRC review rather than the end point of the NRC review (i.e., NRC review of a licensee using those numbers would be less detailed, but lower margins would require a more detailed NRC review); and (2) this would make the guidance less effective in risk-informing the NRC review. Further, there is no 0.02 minimum margin in any of the current ANS standards (i.e, there was in the past, but during the revision of those standards, the 0.02 margin was removed).

NRC appreciated that the comments were appropriate and of high-quality and that the workshop is the location for getting those comments. However, NRC did not provide in previous SERs the justification for the margin. Also, it is not clear that the licensees had in the past provided sufficient technical justification to NRC. Further, the recent license amendments demonstrated that the NRC was unable to readily conclude that the technical justifications provided by the licensees were adequate, technically appropriate, and readily available.

A member of the public offered the assistance of the ANS standards community to help NRC in improving the text language of draft FCSS-ISG-10.

A member of the public agreed with NRC and Industry about the need to clarify in draft FCSS-ISG-10 the linkage between the margin and the effect of sensitivity of the margin to safety and operational parameters. NRC agreed that the information is in draft FCSS-ISG-10 and understands the request to put that information earlier in the document.

Specifically on issue (2), Industry indicated that:

- For nuclear criticality safety (NCS) at a site, the percentage of effort is:
  - 40% for understanding the systems/processes/handling on the floor
  - 20% for doing calculations, with a subset being validation/benchmarking;
  - 40% for implementation issues;
- Resources needed for draft FCSS-ISG-10 are more than the middle 20%, which represent an unbalanced effort for NCS; and
- Draft FCSS-ISG-10 is not risk-informed because it is not looking at the safety of the system.

NRC noted that draft FCSS-ISG-10 is only focused on the validation/benchmarking, so there is no mismatch in resources.

Industry recommended that NRC focus on the computer modeling of the system (i.e., is it accurate?) rather than on arbitrary margin, area of applicability, etc. Therefore, the issues in draft FCSS-ISG-10 will be put into their proper context. In addition, an NRC site visit prior to reviewing the models would be extremely helpful. During license renewal, it is not appropriate if half the questions are on validation/benchmarking.

NRC noted that a greater percentage of questions may have to do with one review area if other areas are unchanged from previous reviews and the area in question has changed or not been subjected to previous review.

Industry indicated that draft FCSS-ISG-10 requires a significant effort. There is too much attention on validation/benchmarking. Validation is only a calculational tool. The real issue is in the implementation side of the licensing process (i.e., NCS program) with commitments and demonstration of meeting those commitments in the license application.

Industry did not understand the increased focus on validation from a risk-informed point-of-view because, in its view, this does not add to safety and appears to invite more questions from NRC.

Industry described its view that, in the past, NRC did look at the validation/benchmarking issue at the site (i.e., headquarters and regional NRC staff), but there has been organizational changes and new personnel such that it appears that the knowledge base has been lost and new people have new questions. Again, since a licensee has committed to ANS-8.1, then the information on validation/benchmarking should be at the site, and NRC can come to the site to review it.

NRC emphasized that after this issue has been looked at and the technical justification for approving the margin is described in the SER, then the focus would be decreased. But, the lack of that information in the SERs plus the experience with recent licensing actions demonstrated that there are issues regarding technical adequacy with validation/benchmarking.

A member of the public understood NRC's point-of-view, that as licensees continue to rely more on computer calculations and less on experiments, the issue of validation/benchmarking is more important.

Specifically on issue (3), Industry indicated that:

- Draft FCSS-ISG-10 should be consistent with the proposed standard ANS-8.24 on validation.

Industry and a member of the public requested that, although ANS-8.24 is not yet completed, NRC wait to revise draft FCSS-ISG-10 until after ANS-8.24 is published. If not, then draft FCSS-ISG-10 should be later revised for consistency with ANS-8.24. The commentors noted that the standard process is an excellent way to get the text language right. It was further suggested that the consensus process and peer review should be used by NRC when developing such guidance. The 0.05 margin is probably a good guess for fuel cycle facilities, but the 0.10 margin is not.

A member of the public disagreed with some of the information in draft FCSS-ISG-10 (e.g., high enriched systems are more sensitive) for non-fuel facility situations (e.g., spent fuel shipping containers). NRC noted that draft FCSS-ISG-10 is for fuel cycle facilities. However, the issue of margin is part of the overall NRC NCS review for both fuel cycle facilities and non-fuel facility situations.

A member of the public recognized that the regulatory authority (e.g., NRC) does have the responsibility to do what it sees fit when developing guidance and does not need approval from Industry or the public to do so.

A member of the public raised an issue regarding "$k_{eff}$ meters" that was placed in the "parking lot." These meters, which do not exist yet, would allow the user to determine the $k_{eff}$ of a system by having the user point a detector at the system and read a value from a meter. This will require a new terminology, new technology, additional regulatory guidance, and makes the '20' in the '40/20/40' percentage effort for NCS at a site more important than ever.

Again, a member of the public requested the logic of draft FCSS-ISG-10 be changed so that the knowledge of how all the information ties together is earlier in the document. The objective is known, the information is present, but the structure needs to be changed.

A member of the public questioned the purpose of margin of subcriticality for safety. For example, is it: (1) $k_{eff}$ for worst-case scenario with margin for 'stuff happens'; or (2) $k_{eff}$ for the real world with margin for 'account for bias and uncertainty'?

General Comments Received on Draft FCSS-ISG-10:

NRC presented information regarding four general comments received on draft FCSS-ISG-10 (see Enclosure 4a). Those items were covered during the two previous discussion topics, so they will not be repeated and no questions or comments were raised.

**Section 2 - Section by Section Discussion of Draft FCSS-ISG-10:**

Draft FCSS-ISG-10 Introduction, Prefatory Discussion, and Definitions:

NRC presented information regarding comments received on these sections of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) draft FCSS-ISG-10 should not specify arbitrary margin because system parameters are a better indication of safety; (2) draft FCSS-ISG-10 does not address margin in using other than computational methods; (3) it is unclear what the distinction is between benchmark and application calculations; (4) draft FCSS-ISG-10 should discontinue use of the term '$k_{true}$'; and (5) the bias is calculated not estimated.

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) recognizing the historical use of the margin and that system parameters is one of the five factors; (2) noting that draft FCSS-ISG-10 is for computational methods; (3) clarifying the language; (4) considering the proposed language change, but there needs to be a term for this because the $k_{eff}$ for a system is generally not known; and (5) noting that the bias is generally not known and must be estimated.

The comments in the Industry handout (see Enclosure 4b) were:

- Terminology should be consistent with ANS-8.1 and -8.17. The definition for Margin of Subcriticicality for Safety (MoS) should be arbitrary margin, and the equation for bias should be consistent with ANS-8.17.
- "Partly due to the historical lack of guidance, there have been significantly different MoS' approved for different fuel cycle facilities over time" is not accurate. Different MoS' were developed because they are "strongly dependent upon the specific processes and conditions at the facility being licensed, which is largely the reason that different facilities have been licensed with different limits" (draft FCSS-ISG-10 Technical Review Guidance).

The following points were made in the discussion between NRC, Industry, and the Public:

A member of the public recommended that NRC use the term $k_{reference}$ rather than $k_{true}$ and will provide further guidance regarding bias to NRC. Also, the commentor also indicated that, in his view, the ‘beta’ term was backwards. After a discussion on the ‘beta’ term, NRC, Industry, and the public agreed that the ‘beta’ term may be used on either side of the equation and, depending on where it was placed, it would be either positive or negative.

NRC will review draft FCSS-ISG-10 for consistency in terminology and definitions. NRC indicated that draft FCSS-ISG-10 was developed partly because of the different margins in current licenses. NRC agreed with Industry that part of that was due to the specific processes and conditions at the different facilities.

<u>Benchmark Similarity:</u>

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) draft FCSS-ISG-10 unduly emphasizes TSUNAMI to the exclusion of other methods; (2) draft FCSS-ISG-10 should not state that input decks should be provided; and (3) isotopes used in calculations should not only be present in the benchmarks, but should also be present in roughly the same proportion.

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) clarifying that TSUNAMI is only one possible method; (2) clarifying that input decks are one means of providing technical information about systems being modeled; and (3) clarifying the language as requested because NRC agrees that isotope proportion is important.

The comments in the Industry handout (see Enclosure 4b) were:

- Draft FCSS-ISG-10's heavy reliance on TSUNAMI may force licensees to adapt to NRC’s practices rather than the NRC overseeing Industry’s practices.
- “This may be accomplished by submitting input decks for both benchmarks and calculations, or by providing detailed drawings, tables, or other such data to the NRC to permit a detailed comparison of system parameters” is not NRC staff guidance but is a direct recommendation to licensees. This should be re-worded.

The following points were made in the discussion between NRC, Industry, and the Public:

Industry requested that NRC clarify that it is all right to use methods other than TSUNAMI and the text in draft FCSS-ISG-10 should be for NRC staff guidance rather than direction to licensees. Industry suggested that the title of draft FCSS-ISG-10 be changed to more accurately reflect and strengthen the link between validation/benchmarking and margin. Industry suggested changing the term ‘input deck’ to ‘code input’ and changing MoS to the term in the ANS standards representing arbitrary margin.

NRC will modify draft FCSS-ISG-10 to be clear that: (1) the methodologies in draft FCSS-ISG-10 are only some of the possible methodologies that licensees can use; (2) the information identified in draft FCSS-ISG-10 are only some of the possible information that licensees can use to demonstrate benchmark and application similarity; (3) the isotopes present in the benchmarks need to in the same proportion as the application; and (4) draft FCSS-ISG-10 is a document to be used by NRC staff. NRC will consider providing more information in draft FCSS-ISG-10 regarding the acceptance criteria for TSUNAMI correlation coefficients.

Industry did not understand the relationship between area of applicability, validation, benchmarking, and margin. Industry suggested that the establishment of bias/bias uncertainty is done before the selection of margin and that the two are independent issues.

NRC explained that the better the benchmarks accurately represent the application, then the less margin is needed. However, fewer appropriate benchmarks means that more margin is needed. Bias/bias uncertainty and margin are related and must be consistent.

A member of the public described how the number of samples is directly related to the bias and that the margin is certainly related to the bias/bias uncertainty. A member of the public requested more guidance on the acceptance criteria for TSUNAMI correlation coefficients. Again, a member of the public expressed the need for consistent definitions and connection with the overall logic of the document, so that there is more explanation and context. A member of the public expressed concern with just having a ‘warm, fuzzy feeling’ for margin without having it well described or characterized. A member of the public requested that NRC adopt the ANS-8.24 definitions (e.g., term ‘Upper Subcritical Limit’) but NRC should not adopt the term $k_{reference}$.

Again, a member of the public expressed concern of what the margin represents. A member of the public suggested that the margin is not ‘arbitrary’ because it is based on items that are not arbitrary. Industry suggested that the margin takes into account things you do not know, as in a ‘fudge factor.’

Industry suggested that NRC change the regulation, standard review plan, and ISG to be consistent with the ANS standards.

NRC agreed to consider those issues, but noted that the ISG also needs to be consistent with the regulation and the standard review plan.

<u>System Sensitivity:</u>

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) modeling and cross-section errors cannot be determined as described; (2) draft FCSS-ISG-10 should broaden the discussion beyond TSUNAMI and direct perturbation; and (3) draft FCSS-ISG-10 should address both sensitivity and uncertainty in this section.

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) clarifying that ‘error’ meant ‘uncertainty’ in methods and data; (2) clarifying that these are just two possible methods of evaluating sensitivity; and (3) NRC agreed that draft FCSS-ISG-10 should clearly address both sensitivity and uncertainty.

The comment in the Industry handout (see Enclosure 4b) was:

- Draft FCSS-ISG-10 needs to acknowledge tools other TSUNAMI. For example, “Two **major** ways to determine the system’s $k_{eff}$ sensitivity...” Both examples rely on or mention TSUNAMI. Industry’s recommendation is that the **major** be revised to **possible**.

The following points were made in the discussion between NRC, Industry, and the Public:

Industry recommended that a change in a parameter's value may not have an effect on the $k_{eff}$ and therefore, issues with sensitivity and uncertainty should be addressed in operations rather than benchmarks.

Again, a member of the public suggested changing the ISG with regard to describing the sensitivity of HEU because it is not true for all applications outside of fuel facilities.

A member of the public suggested changing 'error' to 'bias' rather than to 'uncertainty.'

Discussion of Neutron Physics of the System:

NRC presented information regarding the comment received on this section of draft FCSS-ISG-10 (see Enclosure 4a). The Industry handout (see Enclosure 4b) did not contain any comments on this section. During the discussion, a member of the public commented that the discussion of unresolved resonance region also applies to the resonance region as a whole. NRC agreed with the comment and will add it to draft FCSS-ISG-10.

Rigor of Validation Methodology:

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) selection of MoS is entirely separate from validation; (2) outliers should only be removed for physical not statistical reasons (i.e., if one benchmark is removed, then the entire set should be suspect); (3) current confidence level of 95% should not be changed; (4) prohibition on positive bias should be removed; (5) statement on global bias not being conservative should be removed; and (6) statement that validation should be exceptionally rigorous should be removed.

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) clarifying that MoS is dependent on validation; (2) agreeing to make that change; (3) clarifying that there is no intent to change confidence levels; (4) clarifying that the reason for the prohibition on positive bias is that reliance should not be placed on errors whose source is not well understood; (5) clarifying that there are demonstratable cases where the prohibition is necessary; and (6) clarifying that the less margin requested means the better validation is needed.

The Industry handout (see Enclosure 4b) did not contain any comments on this section.

The following points were made in the discussion between NRC, Industry, and the Public:

Again, Industry did not understand the relationship between validation, benchmarking, and margin. Industry suggested that additional clarifying language in draft FCSS-ISG-10 is needed.

NRC presented real world examples where unidentified licensees used incorrect validation, area of applicability, etc. to determine a margin that was not sufficient.

NRC, Industry, and the public discussed the term 'positive bias,' and an NRC staff member provided additional language (i.e., it is not allowed to use bias to lower the calculated $k_{eff}$) that may clarify the issue in the next revision to draft FCSS-ISG-10. NRC will entertain a request to use positive bias if there is an appropriate justification for its use.

Industry requested that the last four sections of the ISG (i.e., benchmark similarity, system similarity, discussion of neutron physics of the system, and rigor of validation methodology) be tied to the: (1) ANS standards; (2) area of applicability, bias, and bias uncertainty; and (3) how they all relate to the margin. NRC understood the comment.

A member of the public suggested that the ISG be modified because the discussions about positive bias and the relationship between validation and margin was not clear in the ISG. Also, the information about validation and area of applicability should be removed from draft FCSS-ISG-10 because draft FCSS-ISG-10 concerns margin while the validation should have already been done. If the statistical method is poorly applied, then the validation is not useful and validation needs to be redone to get a new margin.

NRC agreed that the validation should already have been done, but there is a consistency relationship between validation and margin. If you extrapolate, interpolate, or extend beyond area of applicability incorrectly, then the margin may not be sufficient. Therefore, draft FCSS-ISG-10 needs to include items to watch out for regarding validation. If poor statistics are used, then the validation can be redone or a larger margin applied.

Margin in System Parameters:

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were that draft FCSS-ISG-10: (1) does not recognize inherent margin in normal and abnormal conditions; and (2) is unclear regarding whether the conservatism is always required or only required in support of margin.

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) noting that facility and process-specific margin is already included as one of the five factors to consider; and (2) margin may be required by commitments, and this does not preclude crediting that margin as part of the justification here.

The comment in the Industry handout (see Enclosure 4b) was:

- "It is generally acknowledged that the margin to criticality in system parameters (termed the margin of safety) is a better indication of the inherent safety of the system than the margin in $k_{eff}$." This reinforces the concern about too much emphasis on validation and benchmarks.

The following points were made in the discussion between NRC, Industry, and the Public:

NRC, Industry and the public agreed that subcriticality is not solely a function of the value of $k_{eff}$. But, everyone agreed that there are other commitments in the license application, which contribute to ensuring subcriticality.

Industry had concerns about having commitments in the license application that are not appropriate because of new interpretations or guidance in the future. Again, this may cause operations to shut down.

NRC clarified that license commitments include both $k_{eff}$ and technical practices (e.g., conservative modeling practices). Both of these combined in the license application contribute the demonstration that a facility's operations are safety subcritical.

A member of the public provided an example regarding the philosophical 'safety' of operations that could lead to an overemphasis on margin rather than safety.

Industry and members of the public suggested that draft FCSS-ISG-10 should be revised to increase the weight of safety due to parameters to that of margin because margin is only a small piece of safety. This emphasis should be placed earlier in the document.

<u>Normal vs. Abnormal Conditions and Statistical Arguments:</u>

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) evaluation of differences between normal and abnormal conditions should be done on site- and facility-specific cases; (2) no direct quantifiable relation between margin and likelihood of criticality from a miscalculation; and (3) ISG is unclear on acceptability of USLSTATS (i.e., what is an acceptable statistical argument?).

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) noting that this is consistent with draft FCSS-ISG-10; (2) clarifying that there is a qualitative relation; and (3) clarifying that comparison of USL-1 and USL-2 is not sufficient to demonstrate adequate margin because margin contains allowances for uncertainties, which may be systematic or statistical.

The Industry handout (see Enclosure 4b) did not contain any comments on this section.

During the discussion, a member of the public suggested the addition of 'prompt detection' because 'prompt correction' cannot occur without 'prompt detection.' NRC agreed with the comment and will add it to draft FCSS-ISG-10.

<u>Technical Review Guidance and Recommendation:</u>

NRC presented information regarding comments received on this section of draft FCSS-ISG-10 (see Enclosure 4a). A summary of the comments were: (1) justification should be provided whatever the margin; (2) should not impose arbitrary specific margin values; (3) increasing margin beyond historically approved values is inappropriate and does not increase safety; (4) it is unclear why the NUREG-1718 statement is needed; (5) justification is needed for why margin of <0.02 is not acceptable; and (6) need to clarify what is meant by "unusual materials or process conditions."

NRC plans to address the comments in the revised draft FCSS-ISG-10 by: (1) noting that the intent of the ISG is to be risk-informed and if margins are sufficiently large then detailed justification is not needed; (2) noting that ISG does not impose any specific values on licensees; (3) noting that ISG will be applied during new applications, license amendments, and renewal, during which historically approved margin values should be demonstrated; (4) noting that since ISG supplements the standard review plans, this notes an inconsistency in justifying margin in

NUREG-1718; (5) clarifying that 0.02 is indicative of the level of uncertainty in the cross-section data and is consistent with NUREG/CR-6698; and (6) clarifying that issue.

The comments in the Industry handout (see Enclosure 4b) were:

- The use of a minimum 0.02 MoS is reasonable.
- This section mentions that an MoS of 0.05 (LEU) and 0.10 (HEU or plutonium) are "historically accepted." However, after verifying that licensee limits do not agree with the proposed limits, what "history" is draft FCSS-ISG-10 using? (see handout for table of current licensees, their limits/margins for accident conditions, and their limits/margins for normal conditions).
- Specifying an MoS of 0.05 (LEU) and 0.1 (HEU or Pu) is too specific, which is not consistent with ANS standards. These limits would impact currently approved licensee limits. Industry's recommendation is to revise to "Reducing the MoS below currently approved limits requires additional justification, which may include . . ." This revision would then agree with draft FCSS-ISG-10 Technical Review Guidance that "an adequate MoS is strongly dependent upon the specific processes and conditions at the facility being licensed, which is largely the reason that different facilities have been licensed with different limits."
- Use of superlatives (e.g., substantial additional justification, unusually high degree of similarity, highly insensitive, with a high degree of confidence, exceptionally rigorous) creates unreasonable expectations. Deleting these superlatives would improve draft FCSS-ISG-10.

The following points were made in the discussion between NRC, Industry, and the Public:

Industry indicated that the 0.02 is acceptable in draft FCSS-ISG-10, but the 0.05 and 0.10 values are not. Industry suggested changing draft FCSS-ISG-10 to reflect: (1) deletion of the 0.05 and 0.10 margin values; (2) that the current license limits are acceptable; or (3) explain what those values will be used for. Also, the draft FCSS-ISG-10 needs to identify the criteria for what to do if the 0.05 or 0.10 values cannot be met. Industry will provide language to modify approximately 5 to 10 sentences to delete the superlatives that make draft FCSS-ISG-10 difficult to meet. Again, Industry requested that NRC revise the draft FCSS-ISG-10 to clarify the linkage between validation and margin. Industry indicated that the draft FCSS-ISG-10 should be re-written to state what the NRC staff should do rather than what the licensee should do. Industry requested that the draft FCSS-ISG-10 provide what is acceptable to NRC staff.

Industry suggested leaving in the 0.02 and taking out the other values because the 0.02 is based on the ANS standards. However, a member of the public provided the historical information that the 0.02 had been in ANS-8.1 (general NCS), was moved to ANS-8.11 (validation) when it was created, but when the information in ANS-8.11 was moved back to ANS-8.1, the 0.02 was removed. Therefore, NRC, Industry, and the public agreed that there was no 0.02 in the ANS standards.

NRC agreed to remove the superlatives language, add clarifying information about the 0.05 and 0.10 values and how they are to be used, and change the language in the draft FCSS-ISG-10 so that it provides guidance to NRC staff when reviewing validation/benchmarking and margin.

**Section 3 - Other Discussions, Next Steps, Caucuses, Summary, Closing, Conclusion, and "Parking Lot" Issues:**

Other Discussions:

There was no NRC presentation on this topic, and there were no comments in the Industry handout (see Enclosure 4b).

The following points were made in the discussion between NRC, Industry, and the Public:

Industry requested clarifications from NRC regarding when an draft FCSS-ISG-10 review needed:

- Is it needed if there is an amendment request for changes in margin, calculational input that affects margin, special nuclear material form, operations, or possession limits?; and
- Is it needed during license renewal?.

NRC responded that the draft FCSS-ISG-10 review needs to be done. After the completion of a review that results in a well-documented technical justification in an SER, if there are no changes in margin, calculational input that affects margin, special nuclear material form, or operations, then the review does not have to be done again. Therefore, the review will be done when either the licensee requests an amendment that requires the review or during license renewal, whichever comes first.

Again, Industry suggested that NRC modify draft FCSS-ISG-10 to change the focus of the margin values so that 0.02 is acceptable. NRC disagrees with that approach because 0.05 and 0.10 do not require much justification, the lower the margin then the more justification is needed, and 0.02 will be the lowest margin that NRC could conceivably find acceptable under narrow circumstances. A margin value of 0.02 would not be universally acceptable, but could be acceptable for certain licensees and/or processes with appropriate technical justification.

Industry questioned whether, if the current margin is 0.03 which is smaller than either the 0.05 or 0.10 in draft FCSS-ISG-10, this means that NRC will look at this issue more closely? NRC indicated that the issue will be reviewed, but draft FCSS-ISG-10 will be modified to more clearly indicate the graded approach of the review, which was NRC's original intent of draft FCSS-ISG-10.

Again, Industry requested that the revised ISG: (1) clearly state what the acceptance criteria for margin is; (2) clearly link validation/benchmark to margin; and (3) be consistent with the ANS standards.

Next Steps:

NRC will revise draft FCSS-ISG-10 and provide it to Industry and the public for a 30-day comment period. NRC requested that comments be submitted under the NRC mechanism for providing comments, but should also be provided directly to Wilkins Smith (wrs@nrc.gov) and Christopher Tripp (cst@nrc.gov) by e-mail or fax (301-415-5955). NRC will determine the schedule after this workshop and will provide it to the attendees.

NRC/Industry Separate Caucuses:

Both NRC and Industry were given the opportunity to caucus separately from one another.

Summary:

Industry reiterated its key issues, which were: (1) potential impacts on currently approved operations in that the 0.10 margin (HEU/Pu) and 0.05 margin (LEU) are too prescriptive and not aligned with current licensee margins; (2) too much emphasis is placed on validation and benchmark experiments and thus, not risk informed; and (3) NRC should ensure that draft FCSS-ISG-10 is consistent with current ANS standards, such as terminology, approach, etc., and NRC may need to revise draft FCSS-ISG-10 after the ANS-8.24 validation standard is issued.

NRC reiterated its key point that draft FCSS-ISG-10 will be revised to more clearly state the logic and be more consistent, but that the key aspects of it will likely not change. The revision will be put out for a 30-day comment period.

Closing:

Industry appreciated the opportunity to provide constructive comments that will contribute to making draft FCSS-ISG-10 a clearer document. The Nuclear Energy Institute will take the lead in getting the upcoming revised draft reviewed and commented upon.

NRC closing remarks thanked the participants for attending the workshop, expressed appreciation to the participants, informed the participants that NRC understood the comments, and committed to revise the document and provide it for public comment. NRC noted that the sooner that Industry provides comments, the better the revised draft FCSS-ISG-10 will be.

Conclusion:

Both Industry and NRC reached greater agreement on the objectives of the ISG and how, accordingly, the FCSS-ISG-10 should be revised. Both Industry and NRC expressed appreciation for the dialogue. NRC stated that it would release the new draft for public comment.

Highlighted points were the following:

- Industry and NRC: Both agreed that draft FCSS-ISG-10 needs to make clear what is acceptable for margin of subcriticality for safety;
- NRC: NRC will revise draft FCSS-ISG-10 to take all the information into account, as appropriate;
- NRC: NRC will issue draft FCSS-ISG-10 for public comment;
- Industry: Industry will provide comment on the revision of draft FCSS-ISG-10 on the schedule requested by NRC; and
- Industry and NRC: Both agreed to continue the communications with each other on draft FCSS-ISG-10.

“Parking Lot” Issues:

During the workshop, the following issues were placed in the “parking lot” for future consideration:

- Development and use of a $k_{eff}$ meter; and
- ANS NCS standards community is willing to assist NRC in revising draft FCSS-ISG-10.

**Enclosures:**
1. Meeting Attendee List
2. Draft FCSS-ISG-10 (ML043290270)
3. Meeting Agenda
4. Draft FCSS-ISG-10 Workshop NRC Presentation Slides/Industry Handout

**U.S. NUCLEAR REGULATORY COMMISSION**
**DRAFT FCSS-ISG-10 WORKSHOP ATTENDEE LIST**

| NAME | ORG. |
|---|---|
| Larry Berg | NRC |
| Chip Cameron | NRC |
| Ted Carter | NRC |
| Jerry Chuang | NRC |
| Dennis Damon | NRC |
| Diana Diaz-Toro | NRC |
| Harry Felsher | NRC |
| Tim Frye | NRC |
| Melanie Galloway | NRC |
| Dennis Galvin | NRC |
| Joseph Giitter | NRC |
| Kim Hammer | NRC |
| Craig Hrabal | NRC |
| Natreon Jordan | NRC |
| John Lubinski | NRC |
| Stewart Magruder | NRC |
| Dennis Morey | NRC |
| Kevin Morrissey | NRC |
| Tamara Powell | NRC |
| Brenda Reilly | NRC |
| Jim Smith | NRC |
| Wilkins Smith | NRC |
| Jeremy Tapp | NRC |
| Christopher Tripp | NRC |
| Ben Wilson | NRC |
| Carl Withee | NRC |
| Jim Colletti | Bettis Atomic Laboratory |
| Tom Dudley | Lockheed Martin KAPL, Inc. |
| Clifton Farrell | Nuclear Energy Institute |
| Ivon Fergus | U.S. Department of Energy |
| Robert Frost | Nuclear Safety Associates |
| Calvin Hopper | Oak Ridge National Laboratory |
| Felix Killar | Nuclear Energy Institute |
| Leland Montieth | Idaho National Laboratory |
| Cecil Parks | Oak Ridge National Laboratory |
| Scott Revolinski | Westinghouse Safety Management Solutions |
| Burt Rothleder | U.S. Department of Energy |
| Daniel Thomas | Bechtel SAIC Company |
| Tomoho Yamada | Japan Nuclear Energy Safety Organization |
| Jason Bolling | Industry |
| Les Duncan | Industry |
| Robert Foster | Industry |
| Dealis Gwyn | Industry |
| Barbara Hubbard | Industry |
| Calvin Manning | Industry |
| Lon Paulson | Industry |
| Randy Shackelford | Industry |
| Charles Vaughan | Industry |
| Larry Wetzel | Industry |
| Ralph Winiarski | Industry |

Enclosure 1

# Interim Staff Guidance-10, Revision 0
# Justification for Minimum Margin of Subcriticality for Safety

**Prepared by**
**Division of Fuel Cycle Safety and Safeguards**
**Office of Nuclear Material Safety and Safeguards**

## Issue

Technical justification for the selection of the minimum margin of subcriticality for safety, as required by 10 CFR 70.61(d).

## Introduction

10 CFR 70.61(d) requires, in part, that licensees demonstrate that "under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety." To demonstrate subcriticality, licensees perform validation studies in which critical experiments similar to actual or anticipated calculations are chosen and are then used to establish a mathematical criterion for subcriticality for all future calculations. This criterion is expressed in terms of a limit on the maximum value of the calculated $k_{eff}$, which will be referred to in this Interim Staff Guidance (ISG) as the upper subcritical limit (USL). The USL includes allowances for bias and bias uncertainty as well as an additional margin which will be referred to hereafter as the minimum margin of subcriticality (MoS). This MoS has been variously referred to within the nuclear industry as *subcritical margin*, *arbitrary margin*, and *administrative margin*. The term MoS will be used throughout this ISG for consistency, but these terms are frequently used interchangeably. This MoS is an allowance for any unknown errors in the calculational method that may bias the result of calculations, beyond those accounted for explicitly in the calculation of the bias and bias uncertainty.

There is little guidance in the fuel facility Standard Review Plans (SRPs) as to what constitutes an acceptable MoS. NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility," Section 5.4.3.4.4, states that the MoS should be pre-approved by the U.S. Nuclear Regulatory Commission (NRC) and that the MoS must "include adequate allowance for uncertainty in the methodology, data, and bias to assure subcriticality." However, there is little guidance on how to determine the amount of MoS that is appropriate. Partly due to the historical lack of guidance, there have been significantly different margins of subcriticality approved for different fuel cycle facilities over time. In addition, the different ways of defining the MoS and calculating $k_{eff}$ limits significantly compound the potential for confusion. The MoS can have a significant effect on facility operations (e.g., storage capacity and throughput) and there has, therefore, been considerable recent interest in decreasing the margins of subcriticality below what has been accepted historically. These two factors–the lack of guidance and the increasing interest in reducing margins of subcriticality–make clarification of what constitutes acceptable justification for the MoS necessary. In general, consistent with a risk-informed approach to regulation, smaller margins of subcriticality require more substantial technical justification.

The purpose of this ISG, therefore, is to provide guidance on determining whether the MoS is sufficient to provide an adequate assurance of subcriticality for safety in accordance with 10 CFR 70.61(d).

**Discussion**

The neutron multiplication factor of a fissile system ($k_{eff}$) depends, in general, on many different physical variables. The factors that can affect the calculated value of $k_{eff}$ may be broadly divided into the following categories: (1) geometric form; (2) material composition; and (3) neutron distribution. The geometric form and material composition of the system determine — together with the underlying nuclear data (e.g., v, χ(E), and the set of cross section data) — the spatial and energy distribution of neutrons in the system (i.e., flux and energy spectrum). An error in the nuclear data or in the modeling of these systems can produce an error in the calculated value of $k_{eff}$. This difference between the calculated and true value of $k_{eff}$ is referred to as the *bias*[1]*.* The bias is defined as the difference between the calculated and true values of $k_{eff}$, by the following equation:

$$\beta = k_{calc} - k_{true}$$

The bias of a critical experiment may be known with a high degree of confidence because the true (experimental) value is known *as a priori* ($k_{true}$ . 1). Because both the experimental and the calculational uncertainty are known, there is a determinable uncertainty associated with the bias. The bias for a calculated system other than a critical experiment is not typically known with this same high degree of confidence, because $k_{true}$ is not typically known. The MoS is therefore an allowance for any unknown errors that may affect the calculated value of $k_{eff}$, beyond those accounted for explicitly in the bias and bias uncertainty. An MoS is needed because the critical experiments chosen will, in general, exhibit somewhat different geometric forms, material compositions, and neutron spectra from those of actual system configurations, and the effect of these differences is difficult to quantify. Bias and bias uncertainty are estimated by calculating the $k_{eff}$ of critical experiments with geometric forms, material compositions, and neutron spectra similar to those of actual or anticipated calculations. However, because of the many factors that can effect the bias, it must be recognized that this is only an estimate of the true bias of the system; it is not possible to guarantee that all sources of error have been accounted for during validation. Thus, use of a smaller MoS requires a greater level of assurance that all sources of uncertainty and bias have been taken into account and that the bias is known with a high degree of accuracy. The MoS should be large compared to known uncertainties in the nuclear data and limitations of the methodology (e.g., modeling approximations, convergence uncertainties). It should be noted that this MoS is only needed when subcritical limits are based on the use of calculational methods, including computer and hand calculations. The MoS is not needed when subcritical limits are based on other methods, such as experiment or published data (e.g., widely accepted handbooks or endorsed industry standards).

Because the nuclear industry has employed widely different terminology regarding validation and margin, it is necessary to define the following terms as used in this ISG. These definitions are for clarity only and are not meant to prescribe any particular terminology.

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[1]There are many different ways of computing bias as used in calculation of the USL. This may be an average bias, a least-squares fitted bias, a bounding bias, etc., as described in the applicant's methodology.

Bias: The difference between the calculated and true values of $k_{eff}$ for a fissile system or set of systems.

Bias Uncertainty: The calculated uncertainty in the bias as determined by a statistical method.

Margin of Subcriticality (MoS): Margin in $k_{eff}$ applied in addition to bias and bias uncertainty to ensure subcriticality (also known as subcritical, arbitrary, or administrative margin). This term is shorthand for "minimum margin of subcriticality."

Margin of Safety: Margin in one or more system parameters that represents the difference between the value of the parameter at which it is controlled and the value at which the system becomes critical. (This represents an additional margin beyond the MoS.)

Upper Subcritical Limit: The maximum allowable $k_{eff}$ value for a system. Generally, the USL is defined by the equation USL = 1 - bias - bias uncertainty - MoS.

Subcritical Limit: The value of a system parameter at which it is controlled to ensure criticality safety, and at which $k_{eff}$ does not exceed the USL (also known as safety limit).

Operating Limit: The value of a system parameter at which it is administratively controlled to ensure that the system will not exceed the subcritical limit.[2]

If the USL is defined as described above, then the MoS represents the difference between the average calculated $k_{eff}$ (including uncertainties) and the USL, thus:

$$MoS = (1 - bias - bias\ uncertainty) - USL.$$

There are many factors that can affect the code's ability to accurately calculate $k_{eff}$ and that can thus impact the analyst's confidence in the estimation of the bias. Some of these factors are described in detail below.

Benchmark Similarity

Because the bias of calculations is estimated based on critical benchmarks with similar geometric form, material composition, and neutronic behavior to the systems being evaluated, the degree of similarity between benchmarks and actual or anticipated calculations is a key consideration in determining the appropriate MoS. The more closely the benchmarks represent the characteristics of systems being validated, the more confidence exists in the calculated bias and bias uncertainty.

Allowing a comparison of the chosen benchmarks to actual or anticipated calculations requires that both the experiments and the calculations be described in sufficient detail to permit independent verification of results. This may be accomplished by submitting input decks for both benchmarks and calculations, or by providing detailed drawings, tables, or other such data to the NRC to permit a detailed comparison of system parameters.

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[2]Not all licensees have a separate subcritical and operating limit. Use of administrative operating limits is optional, because the subcritical limit should conservatively take parametric tolerances into account.

In evaluating benchmark similarity, some parameters are obviously more significant than others. The parameters that can have the greatest effect on the calculated $k_{eff}$ of the system are those that are most significant. Historically, some parameters have been used as trending parameters because these are the parameters that are expected to have the greatest effect on the bias. They include the moderator-to-fuel ratio (e.g., H/U, H/X, $v^m/v^f$), isotopic abundance (e.g., uranium-235 ($^{235}$U), plutonium-239 ($^{239}$Pu), or overall Pu-content), and parameters characterizing the neutron spectrum (e.g., energy of average lethargy causing fission (EALF), or average energy group (AEG)). Other parameters, such as material density or overall geometric shape, are generally considered to be of less importance. Care should be taken that, when basing the justification for a reduced MoS on the similarity of benchmarks to actual or anticipated calculations, all important system characteristics that can affect the bias have been taken into consideration. There are several ways to demonstrate that the chosen benchmarks are sufficiently similar to actual or anticipated calculations:

1. NUREG/CR-6698, "Guide to Validation of Nuclear Criticality Safety Calculational Method," Table 2.3, contains a set of screening criteria for determining benchmark applicability. As is stated in the NUREG, these criteria were arrived at by consensus among experienced nuclear criticality safety specialists and may be considered conservative. The NRC staff considers agreement on all screening criteria to be sufficient justification for demonstrating benchmark similarity. However, less conservative (i.e., broader) screening ranges may be used if appropriately justified.

2. Use of an analytical method that systematically quantifies the degree of similarity between benchmarks and design applications, such as Oak Ridge National Laboratory's TSUNAMI code in the SCALE 5 code package.

   TSUNAMI calculates a correlation coefficient indicating the degree of similarity between each benchmark and calculation in pair-wise fashion. The appropriate threshold value of the parameter indicating a sufficient degree of similarity is an unresolved issue with the use of this method. However, the NRC staff currently considers a correlation coefficient $c_k$ / 0.95 to be indicative of a strong degree of similarity. Conversely, a correlation coefficient less than 0.90 should not be used as demonstration of benchmark similarity without significant additional justification. These observations are tentative and are based on the staff's observation that benchmarks and calculations having a correlation of at least 95 percent also appear to be very similar based on a traditional comparison of system parameters. TSUNAMI should not be used as a "black box," but may be used to inform the benchmark selection process, due to the evolving nature of this tool.

3. Sensitivity studies may be employed to demonstrate that the system $k_{eff}$ is highly insensitive to a particular parameter. In such cases, a significant error in the parameter will have a small effect on the system bias. One example is when the number density of certain trace materials can be shown to have a negligible effect on $k_{eff}$. Another example is when the presence of a strong external absorber has only a slight effect on $k_{eff}$. In both cases, such a sensitivity study may be used to justify why agreement with regard to a given parameter is not important for demonstrating benchmark similarity.

4. Physical arguments may be used to demonstrate benchmark similarity. For example, the fact that oxygen and fluorine are almost transparent to thermal neutrons (i.e., cross sections are very low) may be used as justification for why the differences in chemical form between $UO_2F_2$ and $UO_2$ may be ignored.

A combination of the above methods may also prove helpful in demonstrating benchmark similarity. For example, TSUNAMI may be used to identify the parameters to which $k_{eff}$ is most sensitive, or a sensitivity study may be used to confirm TSUNAMI results or justify screening ranges. Care should be taken to ensure that all parameters which can measurably affect the bias are considered when comparing chosen benchmarks to calculations. For example, comparison should not be based solely on agreement in the $^{235}U$ fission spectrum if $^{238}U$ or $^{10}B$ absorption or $^{1}H$ scattering have a significant effect on the calculated $k_{eff}$. A method such as TSUNAMI that considers the complete set of reactions and nuclides present should be used rather than relying on a comparison of only the fission spectra. That all important parameters have been included can be determined based on a study of the $k_{eff}$ sensitivity, as discussed in the next section. It is especially important that all materials present in calculations that can have more than a negligible effect on the bias are included in the chosen benchmarks. In addition, it is necessary that if the parameters associated with calculations are outside the range of the benchmark data, the effect of extrapolating the bias should be taken into account in setting the USL. This should be done by making use of trends in the bias. Both the trend and the uncertainty in the trend should be extrapolated using an established mathematical method.

Some questions that should be asked in evaluating the chosen benchmarks include:

- Are the critical experiments chosen all high-quality benchmarks from reliable (e.g., peer-reviewed and widely-accepted) sources?
- Are the benchmarks chosen taken from independent sources?
- Do the most important benchmark parameters cover the entire range needed for actual or anticipated calculations?
- Is the number of benchmarks sufficient to establish trends in the bias across the entire range? (The number depends on the specific statistical method employed.)
- Are all important parameters that could affect the bias adequately represented in the chosen benchmarks?

<u>System Sensitivity</u>

Sensitivity of the calculated $k_{eff}$ to changes in system parameters is a closely related concept to that of similarity. This is because those parameters to which $k_{eff}$ is most sensitive should weigh more heavily in evaluating benchmark similarity. If $k_{eff}$ is highly sensitive to a given parameter, an error in the parameter could be expected to have a significant impact on the bias. Conversely, if $k_{eff}$ is very insensitive to a given parameter, then an error would be expected to have a negligible impact on the bias. In the latter case, agreement with regard to that parameter is not important to establishing benchmark similarity.

Two major ways to determine the system's $k_{eff}$ sensitivity are:

1. The TSUNAMI code in the SCALE 5 code package can be used to calculate the sensitivity coefficients for each nuclide-reaction pair present in the problem. TSUNAMI calculates both an integral sensitivity coefficient (i.e., summed over all energy groups) and a sensitivity profile as a function of energy group. The sensitivity coefficient is defined as the fractional change in $k_{eff}$ for a 1 percent change in the nuclear cross

section. It must be recognized that TSUNAMI only evaluates the $k_{eff}$ sensitivity to changes in the nuclear data, and not to other parameters that could affect the bias and should be considered.

2. Direct sensitivity calculations can also be used to perturb the system and gauge the resulting effect on $k_{eff}$. Perturbation of the atomic number densities can also be used to confirm the integral sensitivity coefficients calculated by TSUNAMI (as when there is doubt as to convergence of the adjoint flux).

The relationship between the $k_{eff}$ sensitivity and confidence in the bias is the reason that high-enriched uranium fuel facilities have historically required a greater MoS than low-enriched uranium facilities. High-enriched systems tend to be much more sensitive to changes in the underlying system parameters, and in such systems, the effect of any errors on the bias would be greatly magnified. For this same reason, systems involving weapons-grade plutonium would also be more susceptible to undetected errors than low-assay mixed oxide (i.e., a few percent Pu). The appropriate amount of MoS should, therefore, be commensurate with the sensitivity of the system to changes in the underlying parameters.

Some questions that should be asked in evaluating the $k_{eff}$ sensitivity include:

- How sensitive is $k_{eff}$ to changes in the underlying nuclear data (e.g., cross sections)?
- How sensitive is $k_{eff}$ to changes in the geometric form and material composition?
- Is the MoS large compared to the expected magnitude of changes in $k_{eff}$ resulting from errors in the underlying system parameters?

<u>Neutron Physics of the System</u>

Another consideration that may affect the appropriate MoS is the extent to which the physical behavior of the system is known. Fissile systems which are known to be subcritical with a high degree of confidence do not require as much MoS as systems where subcriticality is less certain. An example of a system known to be subcritical would be a finished fuel assembly. These systems typically can only be made critical when highly thermalized, and due to extensive analysis and reactor experience, the flooded case is known to be subcritical in isolation. In addition, the thermal neutron cross sections for materials in finished reactor fuel have been measured with an exceptionally high degree of accuracy (as opposed to the unresolved resonance region). Other examples may include systems consisting of very simple geometry or other idealized situations in which there is strong evidence that the system is subcritical based on comparisons with highly similar systems in published references such as handbooks or standards. In these cases, the amount of MoS needed may be significantly reduced.

An important factor in determining that the neutron physics of the system is well-known is ensuring that the configuration of the system is fixed. For example, a finished fuel assembly is subject to tight quality assurance checks and has a form that is well-characterized and highly stable. A solution or powder process with a complex geometric arrangement would be much more susceptible to having its configuration change to one whose neutron physics is not well-understood. Experience with similar processes may also be credited.

Some questions that should be asked in evaluating the neutron physics of the system include:

- Is the geometric form and material composition of the system rigid and unchanging?
- Is the geometric form and material composition of the system subject to strict quality assurance?
- Are there other reasons besides criticality calculations to conclude that the system will be subcritical (e.g., handbooks, standards, reactor fuel studies)?
- How well-known are the cross sections in the energy range of interest?

Rigor of Validation Methodology

Having a high degree of confidence in the estimated bias and bias uncertainty requires both that there be a sufficient quantity of well-behaved benchmarks and that there be a sufficiently rigorous validation methodology. If either the data or the methodology is not adequate, a high degree of confidence in the results cannot be attained. The validation methodology must also be suitable for the data analyzed. For example, a statistical methodology relying on the data being normally distributed about the mean $k_{eff}$ would not be appropriate to analyze data that are not normally distributed. A linear regression fit to data that has a non-linear bias trend would similarly not be appropriate.

Having a sufficient quantity of well-behaved benchmarks means that: (1) there are enough (applicable) benchmarks to make a statistically meaningful calculation of the bias and bias uncertainty; (2) the benchmarks span the entire range of all important parameters, without gaps requiring extrapolation or wide interpolation; and (3) the benchmarks do not display any apparent anomalies. Most of the statistical methods used rely on the benchmarks being normally distributed. To test for normality, there must be a statistically significant number of benchmarks (which may vary depending on the test employed). If there is insufficient data to verify normality to at least the 95 percent confidence level, then a non-parametric technique should be used to analyze the data. In addition, the benchmarks should provide a continuum of data across the entire validated range so that any variation in the bias as a function of important system parameters may be observed. Anomalies that may cast doubt on the results of the validation may include the presence of discrete clusters of experiments having a lower calculated $k_{eff}$ than the set of benchmarks as a whole, an excessive fluctuation in $k_{eff}$ values (e.g., having a $\chi^2/N$ » 1), or discarding an unusually high number of benchmarks as outliers (i.e., more than 1-2 percent).

Having a sufficiently rigorous validation methodology means having a methodology that is appropriate for the number and distribution of benchmark experiments, that calculates the bias and bias uncertainty using an established statistical methodology, that accounts for any trends in the bias, and that accounts for all apparent sources of uncertainty in the bias (e.g., the increase in uncertainty due to extrapolating the bias beyond the range covered by the benchmark data).

In addition, confidence that the code's performance is well-understood means the bias should be relatively small (i.e., bias . 2 percent), or else the reason for the bias should be known, and no credit must be taken for positive bias. If the absolute value of the bias is very large (especially if the reason for the large bias is unknown), this may indicate that the calculational method is not very accurate, and a larger MoS may be appropriate.

Some questions that should be asked in evaluating the data and the methodology include:

- Is the methodology consistent with the distribution of the data (e.g., normal)?
- Are there enough benchmarks to determine the behavior of the bias across the entire area of applicability?
- Does the assumed functional form of the bias represent a good fit to the benchmark data?
- Are there discrete clusters of benchmarks for which the overall bias appears to be non-conservative (especially consisting of the most applicable benchmarks)?
- Has additional margin been applied to account for extrapolation or wide interpolation?
- Have all apparent bias trends been taken into account?
- Has an excessive number of benchmarks been discarded as statistical outliers?

Performance of an adequate code validation alone is not sufficient justification for any specific MoS. The reason for this is that determination of the bias and bias uncertainty is separate from selection of an appropriate MoS. Therefore, performing an adequate code validation alone is not sufficient demonstration that an appropriate MoS has been chosen.

<u>Margin in System Parameters</u>

The MoS is a reflection of the degree of confidence in the results of the validation analysis; the MoS is a margin in $k_{eff}$ to provide a high degree of assurance that fissile systems calculated to be subcritical are in fact subcritical. However, there are other types of margin that can provide additional assurance of subcriticality; these margins are frequently expressed in terms of the system parameters rather than $k_{eff}$. It is generally acknowledged that the margin to criticality in system parameters (termed the *margin of safety*) is a better indication of the inherent safety of the system than margin in $k_{eff}$. In addition to establishing subcritical limits on controlled system parameters, licensees frequently establish operating limits to ensure that subcritical limits are not exceeded. The difference between the subcritical limit and the operating limit (if used) of a system parameter represents one type of margin that may be credited in justifying a lower MoS than would be otherwise acceptable. This difference between the subcritical limit and the operating limit should not be confused with the MoS. Confusion often arises, however, because systems in which $k_{eff}$ is highly sensitive to changes in process parameters may require both: (1) a large margin between subcritical and operating limits, and (2) a large MoS. This is because systems in which $k_{eff}$ is highly sensitive to changes in process parameters are highly sensitive to normal process variations and to any potential errors. Both the MoS and the margin between the subcritical and operating limits are thus dependent on the $k_{eff}$ sensitivity of the system.

In addition to the margin between the subcritical and operating limits, there is also usually a significant amount of conservatism in the facility’s technical practices with regard to modeling. In criticality calculations, controlled parameters are typically analyzed at their subcritical limits, whereas uncontrolled parameters are analyzed at their worst-case credible condition. In addition, tolerances must be conservatively taken into account. These technical practices generally result in conservatism of at least several percent in $k_{eff}$. Examples of this conservatism may include assuming optimum concentration in solution processes, neglect of neutron absorbers in structural materials, or requiring at least a 1-inch, tight-fitting reflector around process equipment. The margin due to this conservatism may be credited in justifying a smaller MoS than would otherwise be found acceptable. However, in order to take credit for this as part of the basis for the MoS, it should be demonstrated that the technical practices committed to in the license application will result in a predictable and consistent amount of conservatism in $k_{eff}$. If this modeling conservatism will not always be present, it should not be used as justification for the MoS.

Some questions that should be asked in evaluating the margin in system parameters include:

- How much margin in $k_{eff}$ is present due to conservatism in the modeling practices?

- Will this margin be present for all normal and credible abnormal condition calculations?

Normal vs. Abnormal Conditions

Historically, several licensees have distinguished between normal and abnormal condition $k_{eff}$ limits, in that they have a higher $k_{eff}$ limit for abnormal conditions. Separate limits for normal and abnormal condition $k_{eff}$ values are permissible but are not required.

There is a certain likelihood associated with the MoS that processes calculated to be subcritical will in fact be critical. A somewhat higher likelihood is permissible for abnormal than for normal condition calculations. This is because the abnormal condition should be at least unlikely to occur in accordance with the double contingency principle. That is, achieving the abnormal condition requires at least one contingency to have occurred and is likely to be promptly corrected upon detection. In addition, there is often additional conservatism present in the abnormal condition because uncontrolled parameters are analyzed at their worst-case credible conditions.

As stated in NUREG-1718, “Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility,” the fact that abnormal conditions meet the standard of being at least unlikely from the standpoint of the double contingency principle may be used to justify having a lower MoS than would be permissible for normal conditions. In addition, the increased risk associated with the less conservative MoS should be commensurate with and offset by the unlikelihood of achieving the abnormal condition. That is, the likelihood that a process calculated to be subcritical will be critical increases when going from a normal to a higher abnormal condition $k_{eff}$ limit. If the normal condition $k_{eff}$ limit is acceptable, then the abnormal limit will also be acceptable provided this increased likelihood is offset by the unlikelihood of going to the abnormal condition because of the controls that have been established. If a single $k_{eff}$ limit is used (i.e., no credit for unlikelihood of the abnormal condition), then it must be determined to be acceptable to cover both normal and credible abnormal conditions.

Statistical Arguments

Historically, the argument has been used that the MoS can be estimated based on comparing the results of two statistical methods. In the USLSTATS code issued with the SCALE code package there are two methods for calculating the USL: (1) the Confidence Band with Administrative Margin Approach, which calculates USL-1, and (2) the Lower Tolerance Band Approach, which calculates USL-2. The MoS is an input parameter to the Confidence Band

Approach but is not included explicitly in the Lower Tolerance Band Approach. Justification that the MoS chosen in the Confidence Band Approach is adequate has been based on a comparison of USL-1 and USL-2 (i.e., the condition that USL-1, including the chosen MoS, is less than USL-2). However, this justification is not sufficient.

The condition that USL-1 is less than USL-2 is necessary, but not sufficient to show that an adequate MoS has been selected. These methods are two different statistical treatments of the data, and a comparison between them can only demonstrate whether the MoS is sufficient to bound statistical uncertainties included in the Lower Tolerance Band Approach but not included in the Confidence Band Approach. There may be other statistical or non-statistical errors in the calculation of $k_{eff}$ that are not handled in the statistical treatments. Therefore, the NRC does not consider this an acceptable justification for selection of the MoS.

**Regulatory Basis**

In addition to complying with paragraphs (b) and (c) of this section, the risk of nuclear criticality accidents must be limited by assuring that under normal and credible abnormal conditions, all nuclear processes are subcritical, including use of an approved margin of subcriticality for safety. [10 CFR 70.61(d)]

**Technical Review Guidance**

Determination of an adequate MoS is strongly dependent upon the specific processes and conditions at the facility being licensed, which is largely the reason that different facilities have been licensed with different limits. Judgement and experience must be employed in evaluating the adequacy of the proposed MoS. Historically, however, an MoS of 0.05 in $k_{eff}$ has generally been found acceptable for a typical low-enriched fuel fabrication facility. This will generally be the case provided there is a sufficient quantity of well-behaved benchmarks and a sufficiently rigorous validation methodology has been employed. For systems involving high-enriched uranium or plutonium, additional MoS may be appropriate to account for the increased sensitivity of $k_{eff}$ to changes in system parameters. There is no consistent precedent for such facilities, but the amount of increased MoS should be commensurate with the increased $k_{eff}$ sensitivity of these systems. Therefore, an MoS of 0.05 in $k_{eff}$ for low-enriched fuel facilities or an MoS of 0.1 for high-enriched or plutonium fuel facilities must be justified but will generally be found acceptable with the caveats discussed above[3].

For facility processes involving unusual materials or new process conditions, the validation should be reviewed in detail to ensure that there are no anomalies associated with unique system characteristics.

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[3]NUREG-1718, Section 6.4.3.3.4, states that the applicant should submit justification for the MoS, but then states that an MoS of 0.05 is "generally considered to be acceptable without additional justification when both the bias and its uncertainty are determined to be negligible." These statements are inconsistent. The statement about 0.05 being generally acceptable without additional justification is in error and should be removed from the next revision to the SRP.

In any case, the MoS should not be reduced below a minimum of 0.02.

Reducing the MoS below 0.05 for low-enriched processes or 0.1 for high-enriched or plutonium processes requires substantial additional justification, which may include:

1. An unusually high degree of similarity between the chosen benchmarks and anticipated normal and credible abnormal conditions being validated.

2. Demonstration that the system $k_{eff}$ is highly insensitive to changes in underlying system parameters, such that the worst credible modeling or cross section errors would have a negligible effect on the bias.

3. Demonstration that the system being modeled is known to be subcritical with a high degree of confidence. This requires that there be other strong evidence in addition to the calculations that the system is subcritical (such as comparison with highly similar systems in published references such as handbooks or standards).

4. Demonstration that the validation methodology is exceptionally rigorous, so that any potential sources of error have been accounted for in calculating the USL.

5. Demonstration that there is a dependable and consistent amount of conservatism in $k_{eff}$ due to the conservatism in modeling practices.

In addition, justification of the MoS for abnormal conditions may include:

> Demonstration that the increased likelihood of a process calculated as subcritical being critical is offset by the unlikelihood of achieving the abnormal condition.

This list is not all-inclusive; other technical justification demonstrating that there is a high degree of confidence in the calculation of $k_{eff}$ may be used.

**Recommendation**

The guidance in this ISG should supplement the current guidance in the nuclear criticality safety chapters of the fuel facility SRPs (NUREG-1520 and -1718). In addition, NUREG-1718, Section 6.4.3.3.4, should be revised to remove the following sentence:

> A minimum subcritical margin of 0.05 is generally considered to be acceptable without additional justification when both the bias and its uncertainty are determined to be negligible."

**References**

U.S. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-1520, "Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility." NRC: Washington, D.C. March 2002.

U.S. Nuclear Regulatory Commission (U.S.) (NRC). NUREG-1718, "Standard Review Plan for the Review of an Application for a Mixed Oxide (MOX) Fuel Fabrication Facility." NRC: Washington, D.C. August 2000.

U.S. Nuclear Regulatory Commission (U.S.) (NRC). NUREG/CR-6698, "Guide for Validation of Nuclear Criticality Safety Calculational Methodology." NRC: Washington, D.C. Date:_____

U.S. Nuclear Regulatory Commission (U.S.) (NRC). NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages." NRC: Washington, D.C. Date:_____

Approved: ________________________________ Date: _________
Director, Division of Fuel Cycle Safety
and Safeguards, NMSS

**AGENDA FOR WORKSHOP ON DRAFT FCSS-ISG-10,**
**"JUSTIFICATION FOR MINIMUM MARGIN OF SUBCRITICALITY FOR SAFETY"**
**U.S. NUCLEAR REGULATORY COMMISSION AUDITORIUM**
**ROCKVILLE, MARYLAND**
**MAY 20, 2005**

| | |
|---|---|
| Purpose: | Workshop on draft FCSS-ISG-10, "Justification for Minimum Margin of Subcriticality for Safety" for nuclear fuel cycle facilities in accordance with 10 CFR Part 70. |
| Objective: | Discussion of the purpose and intent of draft FCSS-ISG-10 by NRC technical staff with, and obtain comments and suggestions for improvement from, industry, stakeholders, and all interested members of the public. |
| Process: | NRC staff initiate key issue discussions and introduce each section of draft FCSS-ISG-10, briefly address prior written comments, and lead further discussions. |
| 7:30 am | Check-in for Security Badging at Two White Flint North, 11545 Rockville Pike |
| 8:00 am | Purpose of Workshop, Introductions, Agenda, and Discussion Process |
| 8:20 am | NRC Presentation on Context/Intent of Draft FCSS-ISG-10 |
| 8:35 am | Industry Presentation on Key Issues |
| 8:50 am | NRC Staff/Industry Discussion of Key Issues |
| 9:20 am | Introduction, Prefatory Discussion, and Definitions |
| 9:40 am | Benchmark Similarity |
| 10:30 am | Break |
| 10:45 am | System Sensitivity |
| 11:25 am | Discussion of Neutron Physics of the System |
| 12:00 pm | Lunch |
| 12:45 pm | Rigor of Validation Methodology |
| 1:30 pm | Margin in System Parameters |
| 2:00 pm | Normal vs. Abnormal Conditions and Statistical Arguments |
| 2:30 pm | Technical Review Guidance and Recommendation |
| 3:00 pm | Break/Caucus (if needed) |
| 3:30 pm | Discussion of Other Topics and Summary |
| 4:30 pm | Adjourn |

Enclosure 3

**ENCLOSURE 4**

**NRC PRESENTATION SLIDES (4a)**

**AND**

**INDUSTRY HANDOUT (4b)**

# DRAFT ISG-10: Justification for the Minimum Margin of Subcriticality (MoS) for Safety

May 20, 2005

# Motivation for ISG-10

- Historical margins increasingly challenged by:
  - Increased reliance on computer calculations of $k_{eff}$
  - Reduced conservatism due to more sophisticated modeling capabilities
  - Increased industry interest in reducing MoS
  - Expansion to new facilities and processes (areas of applicability)
- Experience in recent licensing reviews
- Lack of existing acceptance criteria
- Need to provide:
  - Systematic, consistent, and risk-informed regulatory approach
  - Sound, documented technical basis

# Purpose of ISG-10

- Provide a basis for evaluating MoS that:
  - Is systematically and consistently applied
  - Is risk-informed
  - Takes facility/process-specific considerations into account
- Provide guidance on *some acceptable ways* to provide adequate assurance of subcriticality
- Facilitate more efficient licensing reviews

# Philosophy/Intent of ISG-10

- Codify thought processes that have been historically used by NRC
- Adopt graded approach:
  – Smaller margins require more justification
  – sufficiently large margins do not need detailed justification
- Address multiple approaches to account for facility and process differences

# Approach of ISG-10

- Present 5 criteria that *may* be used to justify MoS (any or all may be applicable):
  - Benchmark similarity
  - System sensitivity
  - Knowledge of neutron physics
  - Rigor of validation methodology
  - Margin in system parameters
- Provide guidance on several possible ways to meet criteria
- Use of other appropriate justification permissible

# Summary of Comments Received

- Replacement of existing ANSI guidance
- Specification of arbitrary values of MoS
- Imposition of new regulatory requirements
- Emphasis on $k_{eff}$ as indicator of safety
- Emphasis on specific methods (TSUNAMI)

- *NRC holding workshop to solicit and clarify comments received in order to finalize guidance*

# General Comments

1. ISG seeking to establish new requirements through “backdoor rulemaking”

2. ANSI standards provide adequate guidance; ISG not needed

3. ISG is subjective; does not contain detailed, quantitative guidance on how to apply the 5 criteria

4. ISG will level playing field among licensees

# General Comments

1. ISGs are guidance; do not contain any requirements. List in ISG of 5 approaches for justifying MoS neither prescriptive nor exclusive.

2. ANSI standards are general and do not contain detailed guidance on selecting MoS. Additional guidance needed because of difficulty in recent licensing actions.

3. Selection of MoS involves judgement. ISG Intended to provide some risk-informed factors to be considered in making informed regulatory decision.

4. Purpose of ISG to provide more consistent regulatory basis that can take facility-specific differences into account.

# Introduction & Definitions

1. Should not specify arbitrary margin in $k_{eff}$; system parameters better indicator of safety

2. Does not address margin in other methods (handbooks, standards, hand calculations)

3. Distinction between benchmark and application calculations unclear

4. Use of term "$k_{true}$" should be discontinued

5. Bias is calculated, not estimated

# Introduction & Definitions

1. ISG codifies historical practice of requiring margin in $k_{eff}$ when relying on methods that calculate $k_{eff.}$ Margin in system parameters considered as one of 5 factors.
2. Guidance specifically focused on margin in $k_{eff.}$ Other methods incorporate varying degrees of conservatism in various forms.
3. Language will be clarified.
4. $K_{true}$ meant to refer to actual neutron multiplication factor for an arbitrary system; not often known.
5. Bias only known precisely if actual $k_{eff}$ known (e.g., critical benchmarks). For arbitrary systems must be estimated by calculating bias for benchmarks similar to applications being validated.

# Benchmark Similarity

1. ISG emphasizes the use of TSUNAMI to exclusion of other methods (e.g., spectral comparison). TSUNAMI is still developing

2. Should not state input decks should be provided

3. Isotopes used in calculations should not only be present in benchmarks; should be present in roughly same proportion

# Benchmark Similarity

1. While TSUNAMI is a developing method, it gives useful insights that can be used to make informed decisions about similarity of benchmarks to design applications. One possible means of demonstrating benchmark similarity
2. Providing input decks one means of describing configuration of systems being modeled (if benchmark similarity part of justification)
3. Materials in benchmarks should be represented in proportion to their importance to calculated $k_{eff}$ in design applications

# System Sensitivity

1. Modeling and cross section errors cannot be determined as required in this section

2. Broaden discussion to more than two methods (TSUNAMI or direct perturbation)

3. Address both sensitivity and uncertainty in this section

# System Sensitivity

1. By “error” is meant “uncertainty” in methods and data. If a cross section error of 50% is required to produce a 1% change in $k_{eff}$, worst credible error will not have measurable effect on the bias

2. Licensee is free to choose other methods for evaluating sensitivity to changes in the system parameters

3. Agree (see example above)

# Neutron Physics

1. Discussion of unresolved resonance region applies to resonance region as a whole

# Neutron Physics

1. Agree. $^{235}U$ and $^{239}Pu$ thermal cross sections known to much higher accuracy than cross sections in resonance region

# Rigor of Validation Methodology

1. Selection of MoS entirely separate from validation
2. Outliers should only be removed for physical, not statistical, reasons. If one benchmark removed, entire set should be suspect
3. Confidence level of 95% should not be changed
4. Remove prohibition on positive bias
5. Remove statement that global bias may not be conservative for discrete clusters of benchmarks
6. Remove statement that validation should be "exceptionally rigorous"

# Rigor of Validation Methodology

1. Greater confidence in validation results means less additional margin needed to provide assurance of subcriticality
2. Agree
3. No intent to change longstanding CLs
4. Positive bias represents inaccuracy in the code; reliance should not be placed on errors whose source is not well-understood
5. Discrete subsets of benchmark experiments may exhibit behavior in the bias different from that of the group as a whole.  May be non-conservative if applications similar to clusters of benchmarks with lower-than-average $k_{eff}$
6. More rigorous validation needed to justify smaller margins

# Margin in System Parameters

1. ISG does not recognize inherent margin in normal and abnormal conditions

2. ISG unclear whether this conservatism is always required or only required in support of MoS

# Margin in System Parameters

1. Facility and process-specific margin provided as one of the 5 factors to be considered

2. Margin may be required by commitments to technical practices in license application. Does not preclude crediting margin as part of justification for MoS

# Normal vs. Abnormal Conditions and Statistical Arguments

1. Evaluation of differences between normal and abnormal conditions should be done on site and facility specific basis

2. No direct, quantifiable relation between margin and likelihood of criticality from miscalculation

3. ISG unclear on whether the USLSTATS approach is acceptable; does not state what would be acceptable statistical argument

# Normal vs. Abnormal Conditions and Statistical Arguments

1. This is consistent with the ISG
2. Agree. However, there is a qualitative relationship between the amount of margin and likelihood of criticality from miscalculation
3. Comparison of USL-1 and USL-2 not sufficient to demonstrate adequate margin. MoS contains allowances for unknown uncertainties, which may be systematic or statistical.

# Technical Review Guidance

1. Justification should be provided whatever MoS
2. Do not arbitrarily impose specific values (0.05 for LEU and 0.1 for HEU)
3. Increasing MoS beyond historically approved values inappropriate, with no increase in safety
4. Unclear why NUREG-1718 statement needed
5. Justification needed why <0.02 not acceptable
6. Clarify what is meant by “unusual materials or process conditions”

# Technical Review Guidance

1. Intent of ISG to be risk-informed and not require detailed justification if margins sufficiently large.
2. ISG does not impose any specific values on licensees
3. ISG will be applied during new applications, license amendments, and renewal, during which historically approved values should be demonstrated
4. Footnote shows that SRP contains inconsistent statements on justifying MoS
5. Indicative of level of uncertainty in cross section data and consistent with NUREG/CR-6698. Recent KENO error illustrates need for reasonable minimum MoS.
6. Agree

**INDUSTRY HANDOUT (Enclosure 4b)**

Les Duncan, BWXT-Lynchburg
Industry Assessment of ISG-10
May 20, 2005

Introduction:

- Industry appreciates the opportunity for open communication.
- Industry appreciates NRC's effort to act as one voice.
- Through these comments, Industry is also attempting to act as one voice.

Industry's Main Concerns:

- Potential impacts on currently approved operations. The 0.10 limit (HEU or plutonium) and 0.05 limit (LEU) are too prescriptive and not aligned with current Licensee limits.
- Too much emphasis on validation and benchmark experiments (not risk informed).
- Ensure that ISG-10 is consistent with current ANS standards (terminology, approach, etc.). Possibly revisit after ANSI/ANS 8.24 (Validation) is issued.

Topic 1: ISG-10 Introduction, Discussion, and Definitions

- Terminology should be consistent with ANS 8.1 and 8.17. The definition for MoS should be arbitrary margin, and the equation for bias should be consistent with ANS 8.17.
- "Partly due to the historical lack of guidance, there have been significantly different margins of subcriticality approved for different fuel cycle facilities over time" is not accurate. Different margins of subcriticality were developed because they're "strongly dependent upon the specific processes and conditions at the facility being licensed, which is largely the reason that different facilities have been licensed with different limits"
  (ISG-10 Technical Review Guidance).

Topic 2: Benchmark Similarity

- ISG-10's heavy reliance on TSUNAMI may force Licensees to adapt to NRC's practices rather than the NRC overseeing Industry practices.
- "This may be accomplished by submitting input decks for both benchmarks and calculations, or by providing detailed drawings, tables, or other such data to the NRC to permit a detailed comparison of system parameters" is not NRC Staff guidance but is a direct recommendation to Licensees. This should be re-worded.

Topic 3: System Sensitivity

- ISG-10 needs to acknowledge tools other than TSUNAMI. For example, "Two **major** ways to determine the system's k-eff sensitivity . . . " Both examples rely on or mention TSUNAMI. Industry's recommendation is that the **major** be revised to **possible**.

Topic 4: Neutron Physics of the System

- No comments.

Topic 5: Rigor of Validation Methodology

- No comments.

Topic 6: Margin of System Parameters

- "It is generally acknowledged that the margin to criticality in system parameters (termed the margin of safety) is a better indication of the inherent safety of the system than the margin in $k_{eff}$." This reinforces the concern about too much emphasis on validation and benchmarks.

Topic 7: Normal vs. Abnormal Conditions and Statistical Arguments

- No comments.

Topic 8: Technical Review Guidance and Recommendation

- The use of a minimum 0.02 MoS is reasonable.
- This section mentions that an MoS of 0.05 (LEU) and 0.10 (HEU or plutonium) are “historically accepted”. However, after verifying that Licensee limits do not agree with the proposed limits, what “history” is ISG-10 using?

| **Facility** | **Accident Conditions** | **Normal Conditions** |
|---|---|---|
| GNF | K+3σ-b#0.97 (LEU) | Same as accident conditions |
| NFS | K+2σ-b#0.95 (HEU)<br>K+2σ-b#0.97 (LEU) | K+2σ-b#0.90 (LEU/HEU) |
| BWXT | K+2σ-b#0.95 (HEU)<br>K+2σ-b#0.97 (LEU)<br>K+2σ-b#0.975 (HEU Special Case) | K+2σ-b#0.92 (HEU)<br>K+2σ-b#0.94 (LEU) |
| F-ANP | K+2σ-b#0.95 (LEU)<br>K+2σ-b#0.98 (LEU, Lynch Special Case) | K+2σ-b#0.87 (LEU) |
| USEC | K+2σ-b#0.97 (LEU)<br>K+2σ#0.9634 (Paducah)<br>K+2σ#0.9605 (Ports HEU/LEU) | Same as accident conditions |
| DCS | K+2σ-b#0.95 (MOX) | Same as accident conditions |
| Westinghouse | K+2σ-b#0.98 (LEU) | K+2σ-b#0.95 (LEU) |

- Specifying an MoS of 0.05 (LEU) and 0.1 (HEU or plutonium) is too specific, which is not consistent with ANS standards. These limits would impact currently approved Licensee limits. Industry’s recommendation is to revise to “Reducing the MoS below currently approved limits requires additional justification, which may include.” This revision would then agree with ISG-10 Technical Review Guidance that “an adequate MoS is strongly dependent upon the specific processes and conditions at the facility being licensed, which is largely the reason that different facilities have been licensed with different limits.”
- Use of superlatives (e.g., substantial additional justification, unusually high degree of similarity, highly insensitive, with a high degree of confidence, exceptionally rigorous) creates unreasonable expectations. Deleting these superlatives would improve ISG-10.

Topic 9: Discussion of Other Topics

- No comments.

Summary of Industry’s Main Comments

- Potential impacts on currently approved operations. The 0.10 limit (HEU or plutonium) and 0.05 limit (LEU) are too prescriptive and not aligned with current Licensee limits.
- Too much emphasis on validation and benchmark experiments (not risk informed).
- Ensure that ISG-10 is consistent with current ANS standards (terminology, approach, etc.). Possibly revisit after ANSI/ANS 8.24 (Validation) is issued.