January 23, 2017

To: Angela Chambers, Program Manager, US DOE Nuclear Criticality Safety Program (NCSP)

From: D. G. Erickson, Chair, US DOE NCSP Criticality Safety Support Group (CSSG)

Subject: CSSG Tasking 2016-04 Response

In tasking 2016-04 a subgroup of the Criticality Safety Support Group (CSSG) was requested to develop a ***Position of the CSSG on Natural Phenomena and Other Extreme Events vis-à-vis ANSI/ANS-8 Standards*** to include a discussion of safety philosophy which implements a graded approach consistent with the understood/interpreted intent of ANSI/ANS-8.1. The CSSG shall explicitly state any interpretive assumptions or philosophies they consider in forming their position. The CSSG is further directed to provide specific language to recommend to ANS-8 for their consideration when revising affected standards.

The CSSG subteam was comprised of the following members:

- Tom McLaughlin (Team Leader)
- Jim Morman
- Jerry Hicks
- Calvin Hopper (CSSG Emeritus)

The attached CSSG Response represents a consensus of the CSSG. Extensive review comments were incorporated into the final version of the Response that is attached to this memo. A minority position by a CSSG member is included as Attachment D to the Response.

Cc: CSSG Members
CSSG Emeritus Members
D. Bowen
L. Scott

Attachment 1: Response to CSSG Tasking 2016-04

Attachment 2: Draft ANS Inquirys related to the Tasking

Attachment 1

RESPONSE TO CSSG TASKING 2016-04

CSSG Position on Natural Phenomena and other Extreme Events
vis-à-vis ANSI/ANS-8 Standards

January 23, 2018

EXECUTIVE SUMMARY

In general, the Department of Energy (DOE) (including the National Nuclear Security Agency [NNSA]) and the Nuclear Regulatory Commission (NRC) and their contractors and licensees are required by law to follow the guidance in national consensus standards when appropriate guidance exists. For criticality safety and criticality accident prevention and emergency response the national consensus standards that provide this guidance are those in the American National Standards Institute (ANSI)/American Nuclear Society (ANS) ANSI/ANS-8 series of standards (hereinafter referred to as ANS-8 standards). In particular, the guidance contained in three of these standards, ANS-8.1 *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*; ANS-8.10, *Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement;* and ANS-8.23, *Nuclear Criticality Accident Emergency Planning and Response,* is most relevant for establishing the basic requirements for criticality accident prevention, response and risk acceptance.

The apparent lack of specificity in some of the guidance in these three standards in particular has led to differing interpretations by subject matter experts. In addition, some DOE regulations require that criticality accidents and their prevention be treated as if they were more significant than the local worker radiation safety hazard that they have been shown to be in actual accident experiences. Together these issues have resulted in recent DOE nuclear safety regulations specifying design requirements that can lead to extreme cost-to-benefit risk analyses and design solutions when other cost-effective solutions, which satisfy the over-arching principles of the ANS-8 standards, may exist. An example was the former DOE requirement to design the Uranium Processing Facility (UPF) to Seismic Design Category 3 to preclude a criticality accident when other simple design solutions could be employed.

This Tasking Response has been prepared by the CSSG in response to CSSG TASKING 2016-04 (included as Attachment A). The tasking directs the CSSG to: (1) develop a safety philosophy that implements a graded approach consistent with the understood intent of ANS-8.1 including any interpretive assumptions or philosophies utilized in forming their position and (2) provide specific language to recommend to ANS for consideration when revising affected ANS-8 standards. In addition, the CSSG has identified some guiding language to be considered for incorporation by DOE in future DOE Standard development/revision efforts.

A minority opinion on this matter by a CSSG member is included in this report as Attachment D.

In response to this tasking, the CSSG recommends that:

1) The DOE should adopt the following nuclear criticality safety philosophy in the development and interpretation of applicable DOE Orders and Standards:

> *It is the philosophy that facility and operation safety limits and controls be established to reduce the risk of a nuclear criticality accident, preferably by prevention, while balancing the costs of those limits and controls using a risk-informed, graded approach that is founded upon an understanding of all of the attendant risks of the operation. Foreseeable criticality accidents should be prevented down to the lower limit of credibility when personnel are at risk of significant radiation exposures, but when operations and facility personnel are not at risk of significant radiation exposures then the acceptable likelihood of the criticality accident could be significantly greater, e.g., "unlikely." These likelihoods descriptors, "credible" and "unlikely," shall be determined by a peer review process and should generally be based on the engineering judgment of SMEs. While always desirable, quantification is often impractical due to lack of data.*

2) The DOE should analyze design basis events for the credible potential to initiate a criticality accident and the subsequent potential for significant radiation exposure of personnel. Vigilance is required to ensure technically-objective graded approaches are applied to maintain pragmatic cost-to-safety-benefit ratios and to avoid the prevention of a particular hazard at the risk of decreasing safety in another area.

3) Requests for clarification, with recommended changes to specific sections of ANS-8 Standards, as discussed under Conclusions and Recommendations, should be submitted to the ANS Standards Manager for distribution to the Nuclear Criticality Safety Consensus Committee (NCSCC). This approach is in keeping with ANSI/ANS Standards Policies and Procedures, which require that interpretations or clarifications of any language within the ANSI/ANS-8.XX standards be submitted to the ANSI/ANS Standards Manager as an 'Inquiry' by the user of the standards.

4) Other, non-ANS-8, national consensus standards developed under the auspices of the ANS Standards Board and found to contain criticality safety guidance should be coordinated with the NCSCC. This is necessary in order to have criticality safety SMEs be involved in the generation, review, and approval of criticality safety guidance as required by ANS Standards policy.

INTRODUCTION

Background

It has been asserted by some that a nuclear criticality accident must be precluded: 1) during or subsequent to extreme events (such as earthquakes and fires of severity equal to their Design Basis Events) or 2) when personnel are not at risk from the radiation consequences of the potential criticality accident. This assertion is based on the current requirement in DOE Order 420.1C, *Facility Safety*, Chapter III:

> *"Criticality safety evaluations must show that entire processes involving fissionable materials will remain subcritical under normal and credible abnormal conditions,* ***including those initiated by design basis events****."*

The above requirement is a paraphrase of ANS-8.1-2014, Section 4.1.2 with the exception of the added bolded text above:

> *Before a new operation with fissionable material is begun or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions.*

However, this one requirement cannot be taken out of the context of the intent and philosophy of the ANS-8 standards taken as a whole. The over-arching safety goal of the ANS-8 standards is that personnel be protected from the consequences of a criticality accident in a cost-effective manner consistent with risk control of other personnel hazards.

The following statements are from ANS-8.l and ANS-8.10:

- "Good safety practices should recognize economic considerations, but the protection of operating personnel and the public is the dominant consideration." (ANS-8.1)
- "Nuclear criticality safety differs in no intrinsic way from industrial safety and good managerial practices apply to both." (ANS-8.1)
- "Distinction may be made between shielded and unshielded facilities, and the criteria may be less stringent when adequate shielding and confinement assure the protection of personnel." (ANS-8.1 and ANS-8.10)
- "If personnel are located remotely from the fissile and fissionable materials, distance may serve in lieu of some or all of the shielding, provided personnel entry into the intervening space is constrained …" (ANS-8.10)
- "Where shielding and confinement are in place the consequences of previous process criticality accidents have been primarily disruption of processes and related costs." (ANS-8.10)

The DOE CSSG position, in accordance with the ANS-8 Standards' guidance, is that foreseeable criticality accidents should be prevented, consistent with the Section 4.1.2 requirement stated above, when personnel are at risk of significant radiation exposures.

Current ANS-8 guidance, other than the few general statements quoted above, is largely silent on cost/risk-benefit issues when personnel are not at risk of significant radiation exposures. The initiating scenario and the likelihood of a subsequent criticality accident, as well as the human consequences subsequent to extreme events such as major facility fires and seismic events can, at best, only be estimated. Perhaps due to this lack of national consensus guidance, the DOE facility contractors (citing DOE regulations, orders, and standards) design and construct facilities and equipment to the overly conservative requirements. This excess conservatism results in excessive delays and costs to the taxpayer inconsistent with the personnel risk associated with a criticality accident hazard. Specifically, DOE and its contractors are attempting to design facilities to preclude the possibility of criticality accidents subsequent to such extreme events even when personnel are not at risk of significant radiation exposure. However, when operations and facility personnel are not at risk of significant radiation exposures then the acceptable likelihood of the criticality accident could be significantly greater, e.g., "unlikely." A 2014 ANS paper authored by four senior criticality safety and ANS-8 SMEs addresses this issue.[1]

This Tasking Response contains requested clarifications and specific suggestions for changes to certain ANS-8 standards to address cost/risk/benefit related issues for extreme accidents and for situations when personnel are not at risk of significant radiation exposures. This Tasking Response also provides discussions of the relevant parts of ANS-8.1-2014 and ANS-8.10-2015 (included as Attachment B), highlighting those sections that do provide a general criticality accident prevention and risk control philosophy.

Further, during investigations performed while generating this Tasking Response, other ANS (but non-ANS-8) standards were found to contain nuclear criticality safety (NCS) guidance. These standards should be coordinated through the NCSCC in order to have criticality safety SMEs be involved in the generation, review, and approval of criticality safety guidance as required by ANS Standards Policy.

CSSG Tasking

Attachment A contains the CSSG Tasking

DISCUSSION

CSSG Nuclear Criticality Safety Philosophy

It is the philosophy of the CSSG that facility and operation safety limits and controls be established to reduce the risk of a nuclear criticality accident, preferably by prevention, while balancing the costs of those limits and controls using a risk-informed, graded approach that is founded upon an understanding of all of the attendant risks of the operation. Foreseeable

[1] Monahan, S. P., McLaughlin, T. P., Mitchell, M. V., and Hayes, D. K., *Fire, Seismic and other Ex-process events and Criticality Safety Risk Acceptance*, ANS Transactions, Vol. 111, pp 854-856.

criticality accidents should be prevented down to the lower limit of credibility when personnel are at risk of significant radiation exposures, but when operations and facility personnel are not at risk of significant radiation exposures then the acceptable likelihood of the criticality accident could be significantly greater, e.g., "unlikely." These likelihoods descriptors, "credible" and "unlikely," shall be determined by a peer review process and should generally be based on the engineering judgment of SMEs. While always desirable, quantification is often impractical due to lack of data.

ANSI/ANS-8 Nuclear Criticality Safety Standards

The practice of nuclear criticality safety (NCS) has been remarkably accident-free in the US since 1964. Much of that success is attributed to the development of the ANSI/ANS-8.xx consensus standards, beginning in the early 1960's, that codified basic, fundamental administrative and technical practices. Six criticality accidents occurred during the 1958 - 1964 period resulting in two deaths and fifteen measurable radiation exposures in excess of national allowance values for radiation workers within facilities [1]. The seventh, and last, criticality accident in the US occurred in 1978 with no radiation exposures, injuries or facility damage. Since the beginning, the ANS-8.xx standards have continued to evolve and to address new and novel process environments and NCS needs.

Though none of these accidents evolved subsequent to natural phenomena events or facility fires, the history of criticality accidents demonstrates, except for immediately nearby workers, rather benign personnel, plant, and environmental radiological consequences from criticality accidents. This includes those that lasted only seconds or minutes and those that continued for hours and required personnel intervention for eventual termination.

It is the general philosophy of the ANS-8 standards to focus on the protection of personnel. Hence, the professional community considers design basis events such as major fires and disruptive earthquakes as potential initiators of a criticality accident. It is reasonable to expect that disruptions to operations such as windstorms, blizzards, small seismic events, small fires, and the like, that may interrupt operations, but physically allow operations to resume fairly readily are reasonable considerations when determining credible abnormal conditions. Events beyond the design basis are clearly beyond consideration unless the consequences could be reduced for minor cost. (i.e. "free safety should be nurtured" Hugh Paxton, LA-3366.) The CSSG has already stated positions related to proper selection of design bases for criticality prevention from a safety viewpoint.

The focus of the criticality safety evaluation should be to control personnel risk to an acceptable level with cost-effective controls. Nuclear criticality safety differs in no intrinsic way from industrial safety, and good managerial practices apply to both. Costs associated with accident recovery and operation resumption are outside the scope of the criticality safety evaluation, however, they may be considered by the operating and regulatory authorities when determining an acceptable risk level.

SME knowledge and judgment has always been the backbone of criticality safety within the US and it remains as such today. The SMEs most involved are process experts and criticality safety

staff, augmented by other discipline experts as appropriate. Documentation of the hazard and accident analysis has expanded greatly, and at significant cost, but risk-control remains paramount.

The current DOE position on criticality accident prevention, documented in Order 420.1C, Chapter III, is that DOE elements and contractors shall satisfy all of the requirements of the ANS-8 standards and, generally, all recommendations. Specifically stated is the requirement of subsection (f):

> *"Criticality safety evaluations must show that entire processes involving fissionable materials will remain subcritical under normal and credible abnormal conditions,* ***including those initiated by design basis events****."*

This requirement is essentially what is stated in ANS-8.1, Section 4.1.2, Process Analysis:

> *"Before a new operation with fissionable material is begun or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions."*

Since "Design Basis Events," as defined by the DOE are "credible" events from a likelihood perspective, these two statements are not judged to be discordant or materially different. However, if either of these statements is applied in isolation then the graded approach and practical cost/risk/benefit considerations will be lost. It is noted that this last, bolded phrase was specifically included to prevent the misapplication of NPH-related regulations. This misapplication could entail a very large cost increase without commensurate benefit.

It is clear that the intent of the ANS-8 standards is to promote cost-effective, common-sense risk control with protection of personnel paramount. However, the ANS-8 standards do not provide any specific interpretation, guidance, or examples regarding the recognition of, or addressing the economic impacts from, applications of interpretations of criticality accident prevention in the face of design basis, or beyond design basis, events that might impact nuclear facilities, workers, the public and the environment. In fact, the Foreword to the over-arching standard on NCS, ANSI/ANS-8.1-2014, provides the explicit statement that the standard:

> *"…does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance."*

A goal of this Tasking Response is to have the relevant standards incorporate, as appropriate, risk-informed and performance-based guidance and a graded approach to quality assurance.

Other, Non-ANS-8, Standards that Address Aspects of Nuclear Criticality Safety

A brief search for other ANS standards that contain criticality safety guidance found two current standards, and one more in development. These are: ANSI/ANS-2.26-2004(R 2010), *Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design,* and ANSI/ANS-58.16-2014, *Safety Categorization and Design Criteria for Nonreactor Nuclear Facilities*; and ANSI/ANS-57.11(under development), *Integrated Safety Assessments for Fuel Cycle Facilities*. The NCSCC and ANS-8 apparently had not been aware of these developments. Based on the memberships of the various committees involved in the development, review and approval of these standards, it seems that the guidance therein that relates to criticality safety has

not been developed, reviewed, and balloted on by NCS SMEs. This is contrary to ANS Standards policy requirements.

Regulatory Developments

Aggressive regulatory developments spawned from 10 CFR 830 and involving all safety disciplines, including NCS, began around 1990. These regulations generally involved several safety categories with NCS being only one topic in these documents. The result was often that NCS SMEs were not appropriately involved in their development and NCS guidance was inserted that was not necessarily consistent with the over-arching philosophy of the ANS-8 standards. It is noted that recent revisions to select DOE standards have involved NCS SMEs and this is regarded as a positive trend. However, the philosophy of over-conservative application of the standards from the past still continues today. The CSSG observes that applications and interpretations of DOE regulations have resulted in extremely excessive cost-to-risk/safety-benefits in existing facilities and new construction projects (e.g., UPF, CMRR).

Over the last several years the CSSG has issued focused Tasking Responses that touch on aspects of both economics in criticality safety and personnel protection in accident prevention [2, 3, 4, 5, 6]. It is apparent that better-delineated ANS-8 statements vis-à-vis extreme accidents, such as major fires and seismic events, that might eventually result in a criticality accident, as well as statements addressing risk-reduction actions, would assist the DOE and perhaps other users of the ANS-8 standards in better understanding and then applying the over-arching intent of the ANS-8 standards.

It is noted that the first ANS-8 standard, containing the essential guidance found in the ANS-8 standards today, was issued in 1964. Since that time there has been only one criticality accident, in 1978, and it was located in a shielded facility and resulted in no significant radiation exposures. This impressive accident record precedes by decades the issuance and requirements from the Nuclear Safety Rule, 10 CFR 830. While perhaps important from a facility safety perspective, this rule has added little benefit, but significant costs, to the practice of criticality safety. An example is:

- Requiring that a "potential for a criticality accident" shall result in the Hazard Category 2 level for a facility [7]. This categorization is not consistent with the local radiological consequences of a criticality accident and makes no allowance for situations where personnel are not at risk of significant radiation exposure. The CSSG has previously documented its position on this issue.

Given that the ANSI/ANS-8.xx standards do *"…not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance.*" some Federal agencies have not realistically or pragmatically acknowledged that: "*Good safety practices should recognize economic considerations, but [that] the protection of operating personnel and the public is the dominant consideration*."[2] Examples of interpretations that have resulted in negative outcomes include:

[2] ANSI/ANS-8.1-2014

- Not acknowledging or crediting shielding or distance as a mitigating factor to minimize radiation exposures, as allowed by ANS-8.1 and ANS-8.10 guidance;
- Imposing the Process Analysis requirement in ANS-8.1, Section 4.1.2, on all credible, and sometimes unknowable upset conditions, regardless of the criticality accident consequences to personnel health;
- Imposing the Process Analysis requirement in ANS-8.1, Section 4.1.2, on largely unknowable, non-process conditions such as severe accident recovery operations, contrary to the intent of the ANS-8 standards.

Consistent application of the ANSI/ANS-8.xx standards by applying the CSSG philosophy and guidance discussed in the Introduction to unlikely events, such as design basis seismic events, should provide the DOE the flexibility to design and construct facilities and equipment in a reasoned, risk-/cost-effective manner. As discussed in Reference 4 the seismic design criteria for criticality accident prevention should be SDC-1 and LS-B or -C.

CONCLUSIONS AND RECOMMENDATIONS

CSSG Position

It is the position of the CSSG that:

1) The DOE should formally recognize, consider and address nuclear criticality accidents as local radiation hazards that do not pose hazardous, or significantly hazardous, circumstances to the co-located worker, public or environment irrespective of the event initiating such an accident.

2) The DOE should adopt the CSSG recommended nuclear criticality safety philosophy in the development and interpretation of applicable DOE Orders and both ANS and DOE Standards.

3) The DOE should minimize guidance on any aspect of criticality safety within its regulations and invoke the ANS-8 standards universally. Examples of this having recently happened include the latest revisions to Order 420.1; STD 3009; STD-1020; STD-1189 and STD 3007(under revision).

4) This Tasking Response should be formally transmitted to the ANS with the requests for clarifications to be considered for inclusion in the ANS-8 standards in order to minimize misunderstandings and misinterpretations and to maximize consistent graded approaches to risk control guidance for criticality accidents, particularly when personnel are not at risk of significant radiation exposures.

Recommendations to ANS

The CSSG recommends that the ANSI/ANS NCSCC, Subcommittee 8 (ANS-8) and its Working Groups (WGs) directly address and provide specific standards guidance regarding safety practices that will employ pragmatic cost-to-safety benefits for ensuring the protection of operating personnel and the public with a level of safety commensurate with other industrial

hazards and their risks. The NCSCC, ANS-8 and designated WGs should be familiar with the references to this Tasking Response on the subject of the potential for external events to cause a criticality accident in order to develop their understanding of and need for this recommendation.

The omission of guidance from ANSI/ANS-8.1-2014 regarding economic considerations and risk in perspective provides the background and bases for similar concerns throughout the balance of all of the ANSI/ANS-8.xx standards, but in particular ANSI/ANS-8.10 and -8.23. This lack of guidance from the ANSI/ANS consensus standards organizations (i.e., Working Groups, Subcommittee and Consensus Committee) has resulted in less than complete information regarding the interpretation, application and accommodation of the standards requirements ("shall") and recommendations ("should") as they relate to the prevention and/or mitigation of criticality accidents that might result from rare, calamitous events at non-reactor nuclear facilities. This is particularly significant for situations when personnel are not at risk of significant radiation exposures.

The CSSG recommends that an ANSI/ANS consensus position be provided that essentially states:

> "Nuclear criticality safety design requirements and operating practices **should** include economic considerations evaluated from graded approaches and risk-informed insights for ensuring the protection of operating personnel, the public, and the environment with a level of safety commensurate with similar-consequence industrial hazards."

Aspects of individual ANS-8 standards that need specificity/clarification/elaboration in order to be able to efficiently implement this over-arching consensus philosophy are listed below.

ANS-8.1, Section 4.1.1 Responsibilities. Management shall establish the criteria to be satisfied by nuclear criticality safety controls. *"Distinction **may** be made between shielded and unshielded facilities, and the criteria **may** be less stringent when adequate shielding and confinement assure the protection of personnel."*

This permissive statement should be a recommendation, with "should" replacing "may."

ANS-8.1, Section 4.1.2 Process Analysis. This requirement is sometimes taken in isolation and misapplied by regulators and in DOE regulations. Suggested words to remedy this situation are:

> Before a new operation with fissionable material is begun or before an existing operation is changed, it shall be determined that the entire process will be subcritical under normal conditions and, *when personnel are present,* under credible abnormal conditions. *When personnel are not at significant risk from the radiation consequences of a criticality accident then the word "credible" should be replaced by "unlikely," consistent with ANS-8.10 guidance. This requirement is not applicable to response and recovery actions for which guidance is provided in ANS-8.23.*

In addition, guidance in Appendix B of ANS-8.1 on the application of the Process Analysis requirement should include "when personnel are not at significant risk" such as subsequent to evacuation from a design basis event or other significant, disruptive event.

ANS-8.10 was written to assure that cost-effective risk-control was applied in the practice of nuclear criticality safety when personnel were not at risk of significant radiation exposure from a criticality accident.

This standard does not explicitly address evacuation and any other condition that removes personnel from, or limits access to, a potentially evolving criticality accident location. Both the Title and the Scope (as well as revised content) must make it clear if the intent of the standard covers all situations when personnel are not at risk of significant radiation exposure from a criticality accident.

ANS-8.23 addresses the evacuation itself and reentry, but should be clarified to discuss that, even if the evacuation is for reasons other than a criticality accident, but that a criticality accident is credible as an evolution of the event causing the evacuation, then reentry should proceed as per **Section 7, Reentry, rescue, stabilization.**

The above instances may not be the only changes needed in the ANSI/ANS-8.xx standards to assure consistency with the recommended overarching philosophy. Thus, it is recommended that all the ANS-8 and other standards be thoroughly reviewed in this context.

Additionally, the ANS Standards organization requires that all standards guidance SHALL be generated and approved by a consensus of SMEs representing each specific technical community. Thus, all criticality safety guidance should be developed under the auspices of the NCSCC. Finally, all non-ANS-8 standards, both existing and under development, should be thoroughly searched for criticality safety guidance. Any criticality safety guidance found in non-ANS-8 standards should be vetted through the NCSCC to either bring the guidance into the appropriate ANS-8 standards or to assure compatibility with the over-arching philosophy of the ANS-8 standards

In summary, the CSSG recommends that:

1) the DOE adopt the following nuclear criticality safety philosophy in the development and interpretation of applicable DOE Orders and Standards:

> *It is the philosophy that facility and operation safety limits and controls be established to reduce the risk of a nuclear criticality accident, preferably by prevention, while balancing the costs of those limits and controls using a risk-informed, graded approach that is founded upon an understanding of all of the attendant risks of the operation. Foreseeable criticality accidents should be prevented down to the lower limit of credibility when personnel are at risk of significant radiation exposures, but when operations and facility personnel are not at risk of significant radiation exposures then the acceptable likelihood of the criticality accident could be significantly greater, e.g., "unlikely." These likelihoods descriptors, "credible" and "unlikely," shall be determined by a peer review process and should generally be based on the engineering judgment of*

SMEs. While always desirable, quantification is often impractical due to lack of data.

2) the CSSG Chairman forward the two attached Inquiries to the ANS Standards Manager along with this Tasking Response which is referenced in both of the Inquiries.

REFERENCES

1. McLaughlin, T. P., Monahan, S. P., Pruvost, N, L., *A Review of Criticality Accidents – 2000 Revision*, Los Alamos National Laboratory report, LA-13638, May 2000.

2. **CSSG Tasking Response 2010-01,** *Balanced Technical Approaches for Addressing Potential Seismically Induced Criticality Accidents in New Facility Design*, see https://ncsp.llnl.gov/docs/tasking_2010/CSSG_Response_to_Tasking_2010_01rev1_final.pdf.

3. **CSSG Tasking Response 2010-02,** *Role of Criticality Safety in Facility Hazard Categorization*, https://ncsp.llnl.gov/docs/tasking_2010/CSSG_Response_to_Tasking_2010-02.pdf.

4. **CSSG Tasking Response 2011-04,** *CSSG Position on Evacuation and Criticality Safety*, https://ncsp.llnl.gov/docs/tasking_2011/Final_CSSG_Tasking_2011-04_Response.pdf.

5 **CSSG Tasking Response 2013-01,** *CSSG Position on Use of Water for Firefighting in Light of Criticality Constraints for DOE Facilities*, https://ncsp.llnl.gov/docs/tasking_2013/CSSGtasking2013-01_28Feb14_.pdf.

6. **CSSG Tasking Response 2014-05,** *CSSG Position on Evacuation and Criticality Safety*, https://ncsp.llnl.gov/docs/tasking_2014/Response_to_TASKING_2014-05-Evacuation_and_CS-Final_11-18-2014_combine.pdf.

7. Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, § 4.1.2.b Nuclear Hazard Category 2 Facilities, DOE-STD-1027-92 December 1992, CHANGE NOTICE NO.1 September 1997, see http://energy.gov/sites/prod/files/2013/06/f2/s1027cn1.pdf.

ATTACHMENT A

CSSG TASKING 2016-04
Date Issued: June 22, 2016

Task Title: ***Position of the CSSG on Natural Phenomena and Other Extreme Events vis-à-vis ANSI/ANS-8 Standards***

Background:

The Department of Energy continues to struggle with the cost-effective application of Section 4.1.2 of ANSI/ANS-8.1 when the abnormal event initiator is a natural phenomena event (e.g. seismic) or other postulated, but credible as defined by the safety analysis community, extreme event causing cataclysmic facility failure. It has been asserted, by some, that a criticality accident must be precluded during all extreme events which cause massive facility failure that alone can cause large numbers of fatalities and that such criticality accident prevention is required by the current wording of ANSI/ANS-8.1-2014 Section 4.1.2.

Consistent with the final statement in the introduction of ANSI/ANS-8.1, "Good safety practices should recognize economic considerations, but the protection of operating personnel and the public is the dominant consideration." the Standard does not purport to nor, propose to, prevent a criticality accident regardless of cost nor to eliminate risk.

The ANS-8 community has had several discussions of this issue but as of yet has not yet provided any strawman language for discussion.

Task Statement:

The CSSG is directed to develop a position on this topic to include a discussion of safety philosophy which implements a graded approach consistent with the understood/interpreted intent of ANSI/ANS-8.1. The CSSG shall explicitly state any interpretive assumptions or philosophies they consider in forming their position. The CSSG is further directed to provide specific language to recommend to ANS-8 for consideration when revising affected standards.

Period of Performance:

The CSSG shall provide their position on criticality prevention during natural phenomena and other extreme events to the NCSP Manager by November 4, 2016.

Resources:

The CSSG shall organize their resources as they deem appropriate and utilize funding provided by the DOE Nuclear Criticality Safety Program for completing this task.

Task Deliverables:

1. Draft text of the response to the entire CSSG: August 25, 2016
2. Comments back to Writing Team: September 9, 2016
3. Final reponse provided to the NCSP Manager: November 4, 2016

Task Completion Date: November 4, 2016

Signed: Jn McKamy

Dr. Jerry N. McKamy, Manager US DOE NCSP
Office of the Chief of Defense Nuclear Safety, NA-511

ATTACHMENT B

Excerpts from ANS-8 Standards

The current overarching ANS-8 guidance for criticality accident prevention is contained in several statements from ANS-8.1 and ANS-8.10 (highlighting added by CSSG).

ANS-8.1: 1 Introduction

Operations with some fissionable materials introduce risks of a criticality accident resulting in a release of radiation that can be lethal to nearby personnel. However, experience has shown that extensive operations can be performed safely and economically when proper precautions are exercised. The few criticality accidents that have occurred show frequency and severity rates far below those typical of nonnuclear accidents. This favorable record can be maintained only by continued adherence to good operating practices such as are embodied in this standard; however, the standard, by itself, cannot establish safe processes in an absolute sense. Good safety practices should recognize economic considerations, but the protection of operating personnel and the public is the dominant consideration. Guidance for establishing an alarm system for protection of personnel is contained in ANSI/ANS-8.3-1997 (R2012) [1].[1)]

ANS-8.1: 4.1.1 Responsibilities

Management shall clearly establish responsibility for nuclear criticality safety … Nuclear criticality safety differs in no intrinsic way from industrial safety, and good managerial practices apply to both. … Management shall establish the criteria to be satisfied by nuclear criticality safety controls. Distinction may be made between shielded and unshielded facilities, and the criteria may be less stringent when adequate shielding and confinement assure the protection of personnel. Guidance is provided in ANSI/ANS-8.10-1983 (R2005).

ANS-8.1: 4.1.2 Process Analysis

Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions.[2)]

[2)] Examples of variations or changes in process conditions or abnormal conditions are provided in Appendix A.

ANS-8.1: B.2 The application of PA

The PA requirement in Sec. 4.1.2 states,

> *"Before a new operation with fissionable material is begun, or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions."*

The clear intent of this requirement is to protect the safety of the worker and the public

during operations with fissionable material. One aspect of meeting the PA requirement is reconciling the phrase "credible abnormal conditions" with Sec. 1, which states,

> *"Good safety practices should recognize economic considerations, but the protection of operating personnel and the public is the dominant consideration." In those facilities where shielding and confinement of fissionable material operations outside reactors meet the requirements in ANSI/ANS-8.10-1983 (R2005) [B.1],[1)] management may accept a higher likelihood of a criticality accident if the worker and public are protected from the potential accident consequences. The word "credible" is not defined in the standard but relies on the judgment of the key professionals involved (nuclear criticality safety staff, operations supervisors, etc.) to determine the credible abnormal conditions for a particular fissionable material operation. The abnormal conditions that are deemed credible can differ from process to process and from site to site. Elimination of all risk is not possible; the goal is to ensure an acceptably low level of risk to workers and the public. Resources expended in the control of criticality accident risks should be consistent with those applied to the control of other hazards with similar consequences.*

ANS-8.10: 4.2.4 Space in Lieu of Shielding

> *"If personnel are located remotely from the fissile and fissionable materials, distance may serve in lieu of some or all of the shielding provided personnel entry into the intervening space is controlled …"*

ANS-8.10: 5. Criticality Safety Practices

> *"Where shielding and confinement were in place, the consequences of previous process criticality accidents have been primarily disruption of processes and related costs [4]. Accordingly, if these consequences are acceptable, an increased likelihood of a criticality accident is acceptable when the consequence to personnel is low due to the facility design. This may be reflected in reduced conservatism in the process analysis. However, plant design and operations are premised on good engineering practices, which dictate that criticality accidents shall not occur under normal and credible abnormal conditions where personnel are at risk."*

The CSSG is convinced that it was not the intent of the original writers and approvers of ANS-8.10 to limit this safety/risk philosophy to only situations where "facility design" limits personnel radiation exposures. This must be recognized by ANS-8 and rectified by a revision to not only this section of ANS-8.10, but the title of the standard and other effected sections. It must be made clear that the intent is to apply this risk philosophy anytime operations personnel are not at risk of significant radiation exposures.

ATTACHMENT C

CSSG Task Team Members

T. P. McLaughlin – LANL retired, CSSG Member, 40 years of NCSCC/ANS-8 involvement, Team Lead

J. E. Hicks – DOE retired, CSSG Member, 25 years of NCSCC/ANS-8 involvement,

C. M. Hopper – ORNL Retired, Ex-Officio CSSG Member, 45 years of NCSCC/ANS-8 involvement,

J. A. Morman – ANL, CSSG Member, 25 years of NCSCC/ANS-8 involvement.

ATTACHMENT D

Objection to the 2016-04 Tasking Response

Dr. Robert E. Wilson

The Response provided by the drafting group was debated during many CSSG meetings but eventually a simple majority agreed it could be issued. I was asked to provide a sketch of views of some others.

The rationale provided for adding 'specificity' to the ANS 8 standards had two major components.

The first rationale presented was the belief that the ANS 8 standards, as drafted by the criticality safety pioneers, were intended to support a more liberal safety posture than is now the common practice. In particular, they would not have addressed with rigor scenarios (e.g. double versus single contingent barriers) involved structural failure following natural phenomenal events, or perhaps a facility fire, but they did not explicitly provide this guidance. The proposed fix is to add this specificity to the standards. The supposition is that the pioneers would have agreed to a much higher accident tolerance if an effective evacuation could be hypothesized or only folks trying to deal with a facility fire were exposed. This belief is suspect. I recall discussing rigorous measures we took to preclude an accident due to an earthquake in a well shielded cell with several pioneers years ago and they did not disagree. We also took steps to protect firefighters in postulated storage area fires and the pioneers seemed OK with such. It is true that in the early days of criticality accidents, operations resumed after a few days and the mission loss was minimum so it could be postulated that they would likewise be unconcerned with the high cost and significant mission loss of criticality accidents since then. From interactions, I see the pioneers as far more pragmatic than that. The 1978 accident in Idaho was in a shielded cell and killed nobody but cost a very large sum and involved a massive mission loss. The pioneers I knew would have noticed.

A second, and hopefully primary, rationale provided by the tasking's originators was that a criticality safety concern was used by ambitious contractors for overbuilding Department of Energy nuclear facilities to inhibit scenarios beyond those considered credible in Criticality Safety Evaluations (CSE). The gateway to this allowance was the facility classification guide in STD 1027. The official method of determining credible criticality accident scenarios is the CSE. If the Process Analysis (or Hazard Assessment) part of the CSE is corrupted by including non-credible scenarios, then the assessment team needs to be strengthened. If suspect arguments are used to add inappropriate scenarios as credible, then more rigorous hazard assessment methods should be used. For example, Probability Risk Assessment methods occasionally helps sharpen the risk picture. All safety disciplines use some cost/risk balance but if suspect scenarios are inserted after the Evaluation is issued, proper authorities need to be informed.

The overbuilding of nuclear facilities is a problem that is worth addressing but it is a political problem that will not be solved by changing ANS 8 standards. In particular, raising the acceptable risk of a criticality accident is the wrong solution. The oversight of DOE construction practices needs to be strengthened and the STD 1027 gateway should be addressed.

Our standards have served us well as written and we do not need a higher probability of accidents.

Attachment 2

AMERICAN NUCLEAR SOCIETY
STANDARDS INQUIRY SUBMITTAL FORM

The American Nuclear Society (ANS) Standards Committee will provide responses to inquiries about requirements, recommendations, and/or permissive statements (i.e., "shall," "should," and "may," respectively) in American National Standards that are developed and approved by ANS. Responses to inquiries will be provided according to the Policy Manual for the ANS Standards Committee. Non relevant inquiries or those concerning unrelated subjects will be returned with appropriate explanation. ANS does not develop case interpretations of requirements in a standard that are applicable to a specific design, operation, facility, or other unique situation only, and therefore is not intended for generic application.

Responses to inquiries on standards are published in the Society's magazine, *Nuclear News*, and are available publicly on the ANS Web site or by contacting the ANS Standards Administrator.

The following information must be provided when submitting a standards inquiry.

Date Inquiry Submitted to ANS: 01/25/2018

INQUIRER

Name: David Erickson

Company or Institutional Affiliation: (if applicable) DOE Criticality Safety Support Group

Title or Position: CSSG Chair

Address:

Telephone: 803-557-9445

E-mail: david.erickson@srs.gov

THE APPLICABLE STANDARD EDITION, SECTION, PARAGRAPH, FIGURE AND/OR TABLE:

ANS-2.26-2004(R 2010); ANS-58-16-2014; ANS-57-11(under development)

PURPOSE(S) OF THE INQUIRY:

It has been discovered that some ANS (but non-ANS-8) standards contain nuclear criticality safety (NCS) guidance that is judged by the Criticality Safety Support Group to be properly contained only in ANS-8 standards and that in some cases this guidance is seemingly inconsistent with ANS-8 philosophy. Any criticality safety guidance found in non-ANS-8 standards should be vetted through the NCSCC to either bring the guidance into the appropriate ANS-8 standards or to assure compatibility with the over-arching philosophy of the ANS-8 standards.

THE INQUIRY STATED IN A CLEAR, CONCISE MANNER:

ANS Standards has designated the NCSCC as the expert committee overseeing the development, review and approval of criticality guidance. It has recently been found that some non-ANS-8 standards now include nuclear criticality safety guidance that has not been developed, reviewed and approved by appropriate subject matter experts. This is contrary to ANS Standards policy and must be rectified. The logical solution to this situation is by vetting this guidance through the NCSCC to either bring the guidance into the appropriate ANS-8 standards or to assure compatibility with the over-arching philosophy of the ANS-8 standards.

A PROPOSED REPLY, IF THE INQUIRER IS IN A POSITION TO OFFER ONE:

See the attached CSSG report 2016-04, Position of the CSSG on Natural Phenomena and Other Extreme Events vis-a-vis ANSI/ANS-8 Standards.

URGENCY (Check One):

☐ Need within 3 months

☑ No immediate urgency

☐ Need by (date): _____

Basis for urgency:

INQUIRIES SHOULD BE ADDRESSED TO:

American Nuclear Society, ATTN: Standards Administrator
555 N. Kensington Avenue; La Grange Park, IL; 60526; or standards@ans.org

AMERICAN NUCLEAR SOCIETY
STANDARDS INQUIRY SUBMITTAL FORM

The American Nuclear Society (ANS) Standards Committee will provide responses to inquiries about requirements, recommendations, and/or permissive statements (i.e., "shall," "should," and "may," respectively) in American National Standards that are developed and approved by ANS. Responses to inquiries will be provided according to the Policy Manual for the ANS Standards Committee. Non relevant inquiries or those concerning unrelated subjects will be returned with appropriate explanation. ANS does not develop case interpretations of requirements in a standard that are applicable to a specific design, operation, facility, or other unique situation only, and therefore is not intended for generic application.

Responses to inquiries on standards are published in the Society's magazine, *Nuclear News*, and are available publicly on the ANS Web site or by contacting the ANS Standards Administrator.

The following information must be provided when submitting a standards inquiry.

Date Inquiry Submitted to ANS: 01/25/2018

INQUIRER

Name: David Erickson

Company or Institutional Affiliation: (if applicable) DOE Criticality Safety Support Group

Title or Position: CSSG Chair

Address:

Telephone: 803-557-9445

E-mail: david.erickson@srs.gov

THE APPLICABLE STANDARD EDITION, SECTION, PARAGRAPH, FIGURE AND/OR TABLE:

ANS-8.1-2014; ANS-8.10-2015; ANS-8.23-2007

PURPOSE(S) OF THE INQUIRY:

The Criticality Safety Support Group requests that the NCSCC/ANS-8 develop and document an over-arching philosophy policy addressing risk/benefit considerations both when operations personnel are at risk of significant radiation exposure as the result of a criticality accident and when they are not at risk of significant radiation exposure. Relatedly, the CSSG requests that guidance be provided in ANS-8.1 and ANS-8.10 that clarifies when this guidance applies. Currently there is not agreement within the practitioner and regulatory community as to: 1) the application of ANS-8.10 for situations such as when evacuation removes personnel from the site of a potentially developing criticality accident; and 2) the application of ANS-8.1 and ANS-8.10 guidance during re-entry and recovery actions, discussed in ANS-8.23, subsequent to an initiating event such as a fire or earthquake.

THE INQUIRY STATED IN A CLEAR, CONCISE MANNER:

ANS-8.1 and ANS-8.10 provide a few general statements concerning criticality accident risk/benefit philosophy:
• “Good safety practices should recognize economic considerations, but the protection of operating personnel and the public is the dominant consideration.”
• “Nuclear criticality safety differs in no intrinsic way from industrial safety and good managerial practices apply to both.”
• “Distinction may be made between shielded and unshielded facilities, and the criteria may be less stringent when adequate shielding and confinement assure the protection of personnel.”
• “If personnel are located remotely from the fissile and fissionable materials, distance may serve in lieu of some or all of the shielding, provided personnel entry into the intervening space is constrained ...”
However, in the Foreword of ANS-8.1 it states: "... does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance."
An over-arching risk/benefit philosophy statement, addressing both when personnel are and are not at risk of significant radiation exposure from a criticality accident needs to be developed and included in ANS-8.1. The ramifications of this policy statement will have implications for additional or changed guidance inANS-8.1; ANS-8.10; and ANS-8.23 and possibly other ANS-8 standards.

A PROPOSED REPLY, IF THE INQUIRER IS IN A POSITION TO OFFER ONE:

See the attached CSSG report 2016-04, Position of the CSSG on Natural Phenomena and Other Extreme Events vis-a-vis ANSI/ANS-8 Standards.

URGENCY (Check One):

☐ Need within 3 months

☑ No immediate urgency

☐ Need by (date): _____

Basis for urgency:

INQUIRIES SHOULD BE ADDRESSED TO:

American Nuclear Society, ATTN: Standards Administrator
555 N. Kensington Avenue; La Grange Park, IL; 60526; or standards@ans.org