



REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 3.71

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NUCLEAR CRITICALITY SAFETY STANDARDS FOR FUELS AND MATERIAL FACILITIES

A. INTRODUCTION

This revised regulatory guide provides license applicants, licensees authorized pursuant to Title 10 of the Code of Federal Regulations, Part 70 (10 CFR Part 70, "Domestic Licensing of Special Nuclear Material"), and certificate holders authorized pursuant to 10 CFR Part 76, "Certification of Gaseous Diffusion Plants," with updated guidance concerning criticality safety standards that the U.S. Nuclear Regulatory Commission (NRC) has endorsed for use with nuclear fuels and material facilities. As such, this guide describes methods that the NRC staff considers acceptable for complying with the NRC's regulations in 10 CFR Parts 70 and 76 (Refs. 1 & 2).

Pursuant to 10 CFR 70.20, "General License to own Special Nuclear Material," a specific license is required to acquire, deliver, receive, possess, use, transfer, import, or export special nuclear material and applications for such licenses must, pursuant to 10 CFR 70.22(a)(8), include proposed procedures to avoid nuclear criticality accidents. Similarly, in 10 CFR Part 76, "Certification of Gaseous Diffusion Plants," certificate holders are required by 10 CFR 76.87(c) to include in their technical safety requirements, appropriate references to procedures and/or equipment that address criticality prevention.

The NRC staff has developed this regulatory guide to provide guidance on complying with these portions of the NRC's regulations. This regulatory guide describes procedures for preventing nuclear criticality accidents in operations that involve handling, processing, storing, and/or transporting special nuclear material at fuel and material facilities. As discussed below, this regulatory guide endorses – with some exceptions – specific nuclear criticality safety standards developed by the American Nuclear Society's Standards Subcommittee 8 (ANS-8), "Operations with Fissionable Materials Outside Reactors." This guide is not intended for use by nuclear reactor licensees.

The NRC issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff needs in reviewing applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions – 1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

Electronic copies of this guide and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading_rm/doc_collections/ and through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading_rm/adams.html, under Accession No. ML103210345. The regulatory analysis may be found in ADAMS under Accession No. ML101440446. Public comments received and the NRC's response to them may be found in ADAMS under Accession No. ML103210349.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required.

This regulatory guide contains information collection requirements covered by 10 CFR Part 70 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0009. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. However, this regulatory guide contains additional information collections that are covered by the requirements of 10 CFR 76.8, "Information Collection Requirements: OMB Approval Not Required," which apply to a wholly owned instrumentality of the United States and affect fewer than 10 respondents. As a result, OMB clearance is not required pursuant to the Paperwork Reduction Act (44 U.S.C. 3501, et seq.). The NRC has determined that this Regulatory Guide is not a major rule as designated by the Congressional Review Act and has verified this determination with the OMB.

B. DISCUSSION

The NRC initially issued Regulatory Guide 3.71 in 1998 to provide guidance concerning procedures that the staff considered acceptable for complying with the agency's regulatory requirements in 10 CFR 70.20, 70.22, and 76.87. Toward that end, the original guide endorsed specific safety standards that ANS-8 developed to provide guidance, criteria, and best practices for use in preventing and mitigating criticality accidents during operations that involve handling, processing, storing, and/or transporting special nuclear material at fuel and material facilities. The original guide also took exceptions to certain portions of individual American National Standards Institute (ANSI)/ANS-8 standards. In addition, the original guide consolidated and replaced a number of earlier NRC regulatory guides, thereby incorporating all of the relevant guidance in a single document.

The American Nuclear Society's Consensus Committee N16 on Nuclear Criticality Safety, as well as the ANSI, approved the ANS-8 standards endorsed in Regulatory Guide 3.71. Additionally, a working group of expert practitioners in the area reviews each ANSI/ANS-8 standard every 5 years so that the standard can be revised, reaffirmed, or withdrawn, as appropriate, to reflect the current state of the art. (This time can be extended to as long as 10 years or more under special circumstances.) New standards are also added when the need arises. Since the timing and issuance of individual standards is independent of the other standards, the list of current standards and their respective dates of issuance is constantly changing.

As a result, since the NRC published Revision 1 to Regulatory Guide 3.71 in 2005, several ANSI/ANS-8 nuclear criticality safety standards have been added, reaffirmed, or revised. Consequently, the NRC staff has updated this guide to provide guidance concerning changes that have occurred since that time. For completeness, this guide also restates the endorsements and exceptions stated in the previous revision, as applicable, while identifying endorsements of or exceptions to new or modified standards. Because the ANSI/ANS-8 standards are constantly being issued, revised, reaffirmed, or withdrawn, the NRC staff plans to revise this guide on a regular basis.

C. REGULATORY POSITION

The ANSI/ANS-8 nuclear criticality safety standards provide criteria and practices that the NRC staff considers generally acceptable for use in preventing and mitigating nuclear criticality accidents. However, use of the ANSI/ANS-8 nuclear criticality safety standards is not a substitute for detailed nuclear criticality safety analyses for specific operations. In addition, inclusion of a reference to another standard in an endorsed standard does not imply NRC endorsement of the referenced standard.

The NRC staff will follow the requirements denoted in the ANSI/ANS-8 standards. The word “shall” in an ANSI/ANS-8 standard denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes permission (neither a requirement nor a recommendation). When a licensee or applicant commits to an ANSI/ANS-8 standard cited in this regulatory guide, the licensee or applicant must perform all operations in accordance with the requirements stated in that standard, but not necessarily with its recommendations. Applicants, licensees, or certificate holders may follow the recommendations given in the ANSI/ANS-8 standards, unless an exception is either (a) stated in this regulatory guide, (b) otherwise specified in 10 CFR Part 70 or 10 CFR Part 76, or (c) addressed by other acceptable methods.

1. ANSI/ANS-8 Nuclear Criticality Standards Endorsed by the NRC.

The NRC endorses the following ANSI/ANS-8 nuclear criticality safety standards without exception:

- a. ANSI/ANS-8.5-1996 (Reaffirmed in 2007), “Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material,” (Ref. 3)
- b. ANSI/ANS-8.6-1983 (Reaffirmed in 2010), “Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ,” (Ref. 4)
- c. ANSI/ANS-8.7-1998 (Reaffirmed in 2007), “Nuclear Criticality Safety in the Storage of Fissile Materials,” (Ref. 5)
- d. ANSI/ANS-8.10-1983 (Reaffirmed in 2005), “Criteria for Nuclear Criticality Safety Controls in Operations With Shielding and Confinement,” (Ref. 6)
- e. ANSI/ANS-8.12-1987 (Reaffirmed in 2002), “Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors,” (Ref. 7)
- f. ANSI/ANS-8.14-2004, “Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors,” (Ref. 8)
- g. ANSI/ANS-8.15-1981 (Reaffirmed in 2005), “Nuclear Criticality Control of Special Actinide Elements,” (Ref. 9)
- h. ANSI/ANS-8.19-2005, “Administrative Practices for Nuclear Criticality Safety,” (Ref. 10)
- i. ANSI/ANS-8.20-1991 (Reaffirmed in 2005), “Nuclear Criticality Safety Training,” (Ref. 11)

- j. ANSI/ANS-8.21-1995 (Reaffirmed in 2001), "Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors," (Ref. 12)
- k. ANSI/ANS-8.22-1997 (Reaffirmed in 2006), "Nuclear Criticality Safety Based on Limiting and Controlling Moderators," (Ref. 13)
- l. ANSI/ANS-8.23-2007, "Nuclear Criticality Accident Emergency Planning and Response," (Ref. 14) and
- m. ANSI/ANS-8.26-2007, "Criticality Safety Engineer Training and Qualification Program." (Ref. 15)

2. **ANSI/ANS-8 Nuclear Criticality Standards Endorsed by the NRC with Exceptions**

The NRC endorses the following ANSI/ANS-8 nuclear criticality safety standards but takes exception to certain sections, as follows:

- a. ANSI/ANS-8.1-1998 (Reaffirmed in 2007), "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors" (Ref. 16)

The guidance on validating calculational methods for nuclear criticality safety, as specified in ANSI/ANS-8.1-1998 (reaffirmed in 2007), provides a practice that is acceptable to the NRC staff for establishing the validity and applicability of calculational methods used in assessing nuclear criticality safety. However, it is not sufficient to merely refer to this standard in describing the validation of a method. Rather, a licensee or applicant should provide the details of validation (as stated in Section 4.3.6 of the standard) to (1) demonstrate the adequacy of the margins of subcriticality relative to the bias and criticality parameters, (2) demonstrate that the calculations embrace the range of variables to which the method will be applied, and (3) demonstrate the trends in the bias upon which the licensee or applicant will base the extension of the area of applicability. In addition, the details of validation should state computer codes used, operations, recipes for choosing code options (where applicable), cross-section sets, and any numerical parameters necessary to describe the input.

- b. ANSI/ANS-8.3-1997 (Reaffirmed in 2003), "Criticality Accident Alarm System" (Ref. 17)

The guidance on criticality accident alarm systems, as specified in ANSI/ANS-8.3-1997 (reaffirmed in 2003), is generally acceptable to the NRC staff. One exception is that 10 CFR 70.24, "Criticality Accident Requirements," requires criticality alarm systems in each area in which special nuclear material is handled, used, or stored. By contrast, Section 4.2.1 of the standard merely requires an evaluation for such areas.

A second exception is that 10 CFR 70.24 and 10 CFR 76.89, (both titled "Criticality Accident Requirements") contain similar provisions requiring that each monitored area be covered by two criticality detectors. By contrast, Section 4.4.1 of the standard permits coverage by a single reliable detector.

A third exception is that 10 CFR 70.24 and 10 CFR 76.89 contain similar provisions requiring that a monitoring system be capable of detecting a nuclear criticality that produces an absorbed dose in soft tissue of 20 rads of combined neutron and gamma

radiation at an unshielded distance of 2 meters from the reacting material within 1 minute. By contrast, Section 5.6 of the standard permits the assumption that the minimum accident of concern delivers the equivalent of an absorbed dose in free air of 20 rads at 2 meters.

- c. ANSI/ANS-8.17-2004 (Reaffirmed in 2009), “Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors” (Ref. 18)

The general safety criteria and criteria to establish subcriticality, as specified in ANSI/ANS 8.17 2004 (reaffirmed in 2009), provide guidance that is acceptable to the NRC staff for preventing nuclear criticality accidents in handling, storing, and transporting fuel assemblies at fuel and material facilities. The only exception is that licensees and applicants may take credit for fuel burnup only when the amount of burnup is confirmed by physical measurements that are appropriate for each type of fuel assembly in the environment in which it is to be stored.

- d. ANSI/ANS-8.24-2007, “Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations” (Ref. 19)

The guidance on establishing bias, bias uncertainty and margins, as specified in ANSI/ANS-8.24-2007, is generally acceptable to the NRC staff. An exception is that a positive bias (i.e., overestimation of k_{eff}) should not be used in determining calculational margin (as stated in Section 6.1.2 of the standard). The use of a positive bias, in general, takes credit for errors in calculating benchmark cases that may or may not be present in actual facility calculations.

A second exception is that the rejection of outliers should be based only on the inconsistency of the data with known physical behavior, rather than on statistical methods (as stated in Section 6.3.2 of the standard). In general, if one data point in an experimental benchmark set is excluded, the entire benchmark set should be excluded. The rejection of outliers, without a physical basis for doing so, may lead to a failure to consider all available information on possible contributions to the bias.

3. ANSI/ANS-8 Nuclear Criticality Standards Withdrawn by the NRC

The NRC has withdrawn its endorsement of ANSI/ANS N2.3-1979, “Immediate Evacuation Signal for Use in Industrial Installations” (Ref 20). Although not an ANSI/ANS-8 standard, this historical standard, which was endorsed in Regulatory Guide 8.5, “Criticality and Other Interior Evacuation Signals,” was consolidated with ANSI/ANS-8.3 in 1986 and subsequently withdrawn by ANS. Therefore, the NRC is withdrawing Regulatory Guide 8.5. Although the NRC has withdrawn its endorsement of the standard, there is nothing technically wrong with this standard, and it is acceptable for use by licensees and applicants.

D. IMPLEMENTATION

This section provides information on how applicants and licensees may use this Regulatory Guide, and how the NRC staff plans to use this guidance.

Applicant and Licensees' Use

Applicants and licensees may use the information in this regulatory guide when developing applications for initial licenses, amendments to licenses, or requests for NRC regulatory approval. Licensees may use the information in this regulatory guide for actions which do not require prior NRC review and approval. Licensees may use the information in this Regulatory Guide or applicable parts to resolve regulatory or inspection issues.

Current licensees may continue to use the guidance found acceptable for complying with specific portions of the regulations as part of their license approval process, which may be a previous version of this Regulatory Guide.

Licensees who believe that the NRC staff is inappropriately imposing this Regulatory Guide as part of a request for a license amendment or request for a change to a previously issued NRC regulatory approval may file a backfitting appeal with the NRC in accordance with 10 CFR 70.76 or 10 CFR 76.76, whichever is applicable.

NRC Staff Use

In issuing this Regulatory Guide, the NRC staff does not intend or approve any imposition of a backfit. The NRC staff does not require, and does not expect, any existing licensee to use or commit to using the guidance in this Regulatory Guide in the absence of a licensee-initiated change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this Regulatory Guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this regulatory guide without further backfit consideration.

During inspections of specific facilities, the staff may suggest or recommend that licensees consider various actions consistent with staff positions in this regulatory guide. Such suggestions and recommendations would not ordinarily be considered backfitting even if prior versions of this Regulatory Guide are part of the licensing basis of the facility with respect to the subject matter of the inspection. However, unless this Regulatory Guide is part of the licensing basis for a plant, a failure to comply with the positions in this Regulatory Guide, by itself, may not be identified by the staff as a violation.

If an existing licensee seeks a license amendment or change to an existing regulatory approval, and the staff's consideration of the request involves a regulatory issue which is directly relevant to this Regulatory Guide and the specific subject matter of the new or revised guidance is an essential consideration in the NRC staff's determination of the acceptability of the licensee's request, the staff may require the licensee to use this Regulatory Guide as a prerequisite for NRC approval. This is not considered backfitting as defined in 10 CFR 70.76(a)(1) and 10 CFR 76.76(a)(1), or a violation of any of the issue finality provisions in 10 CFR Parts 70 and 76.

Conclusion

This regulatory guide is not being imposed upon current licensees and may be voluntarily used by existing licensees. In addition, this Regulatory Guide is issued in conformance with all applicable internal NRC policies and procedures governing backfitting. Accordingly, the NRC's staff issuance of this regulatory guide is not considered backfitting, as defined in the regulations, nor is it deemed to be in conflict with any issue finality provisions.

REFERENCES¹

1. 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," U.S. Nuclear Regulatory Commission, Washington, DC
2. 10 CFR Part 76, "Certification of Gaseous Diffusion Plants," U.S. Nuclear Regulatory Commission, Washington, DC
3. ANSI/ANS-8.5-1996 (Reaffirmed in 2007), "Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material," American Nuclear Society, La Grange Park, Illinois, U.S.A.²
4. ANSI/ANS-8.6-1983 (Reaffirmed in 2010), "Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ," American Nuclear Society, La Grange Park, Illinois, U.S.A.
5. ANSI/ANS-8.7-1998 (Reaffirmed in 2007), "Nuclear Criticality Safety in the Storage of Fissile Materials," American Nuclear Society, La Grange Park, Illinois, U.S.A.
6. ANSI/ANS-8.10-1983 (Reaffirmed in 2005), "Criteria for Nuclear Criticality Safety Controls in Operations With Shielding and Confinement," American Nuclear Society, La Grange Park, Illinois, U.S.A.
7. ANSI/ANS-8.12-1987 (Reaffirmed in 2002), "Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors," American Nuclear Society, La Grange Park, Illinois, U.S.A.
8. ANSI/ANS-8.14-2004, "Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors," American Nuclear Society, La Grange Park, Illinois, U.S.A.
9. ANSI/ANS-8.15-1981 (Reaffirmed in 2005), "Nuclear Criticality Control of Special Actinide Elements," American Nuclear Society, La Grange Park, Illinois, U.S.A.
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12. ANSI/ANS-8.21-1995 (Reaffirmed in 2001), "Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors," American Nuclear Society, La Grange Park, Illinois, U.S.A.
13. ANSI/ANS-8.22-1997 (Reaffirmed in 2006), "Nuclear Criticality Safety Based on Limiting and Controlling Moderators," American Nuclear Society, La Grange Park, Illinois, U.S.A.
14. ANSI/ANS-8.23-2007, "Nuclear Criticality Accident Emergency Planning and Response," American Nuclear Society, La Grange Park, Illinois, U.S.A.

¹ All publicly available NRC documents are available electronically through the Electronic Reading Room on the NRC's public Web site at http://www.nrc.gov/reading_rm/doc_collections/cfr/. The documents can also be viewed on-line for free or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone (301) 415-4737 or (800) 397-4209; fax (301) 415 3548; and e mail pdr.resource@nrc.gov.

² Copies of American National Standards Institute (ANSI) /American Nuclear Society (ANS) standards may be purchased from the ANS Web site (<http://www.new.ans.org/store/>) or by writing to: American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60526, U.S.A., Telephone 800-323-3044.

15. ANSI/ANS-8.26-2007, "Criticality Safety Engineer Training and Qualification Program." American Nuclear Society, La Grange Park, Illinois, U.S.A.
16. ANSI/ANS-8.1-1998 (Reaffirmed in 2007), "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors" American Nuclear Society, La Grange Park, Illinois, U.S.A.
17. ANSI/ANS-8.3-1997 (Reaffirmed in 2003), "Criticality Accident Alarm System" American Nuclear Society, La Grange Park, Illinois, U.S.A.
18. ANSI/ANS-8.17-2004 (Reaffirmed in 2009), "Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors" American Nuclear Society, La Grange Park, Illinois, U.S.A.
19. ANSI/ANS-8.24-2007, "Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations" American Nuclear Society, La Grange Park, Illinois, U.S.A.
20. ANSI/ANS N2.3-1979, "Immediate Evacuation Signal for Use in Industrial Installations" American Nuclear Society, La Grange Park, Illinois, U.S.A.