

American Nuclear Society

**nuclear criticality safety in operations with
fissionable materials outside reactors**

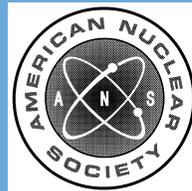
an American National Standard

REAFFIRMED

November 29, 2018

ANSI/ANS-8.1-2014 (R2018)

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**American National Standard
Nuclear Criticality Safety in Operations with
Fissionable Materials Outside Reactors**

Secretariat
American Nuclear Society

Prepared by the
**American Nuclear Society
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Working Group ANS-8.1**

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American National Standard

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American National Standard ANSI/ANS-8.1-2014

Foreword (This Foreword is not a part of American National Standard “Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors,” ANSI/ANS-8.1-2014.)

This standard provides guidance for the prevention of criticality accidents in the handling, storing, processing, and transportation of fissionable material. It was first approved as American Standard N6.1-1964. A substantial revision that included the specification of subcritical limits applicable to process variables was approved as American National Standard N16.1-1969 and was affirmed, with minor revisions, as American National Standard N16.1-1975/ANS-8.1. It was subsequently supplemented by American National Standard for Validation of Calculational Methods for Nuclear Criticality Safety, ANSI N16.9-1975/ANS-8.11. The two standards were consolidated in 1983.

The subcritical limits given in the standard make no allowance for operating contingencies (e.g., double batching) or for inaccurate knowledge of process variables (e.g., concentrations, masses, and dimensions) and are “maximum subcritical limits” for the stated conditions. That is, under the stated conditions, the limits are close enough to critical to provide little incentive for attempting to justify slightly larger values, but concomitantly, they are confidently expected actually to be subcritical. The stated conditions (infinitely long cylinders, absence of neutron-absorbing vessel wall, plutonium solutions without free nitric acid, etc.) are unlikely to be approached in practice; hence, if a limit is reached, there will ordinarily be a larger margin of subcriticality than the minimal value used in its derivation. However, no account was taken of this unlikelihood in setting the limits. It is legitimate for the users of the standard, if they so choose, to make conservative adjustments in the limits to take advantage of the extent to which process conditions may deviate from stated conditions, e.g., to increase a cylinder diameter limit to take advantage of a finite height and of neutron absorption in steel walls.

The present revision of the standard is primarily intended to clarify the use and interpretation of the process analysis requirement, the double-contingency-principle recommendation, and their relationship in a new Appendix. In addition, the definitions for “parameter” and “process conditions” were added to assist with the understanding of the double-contingency recommendation. These and other minor changes were made that do not change the intent of the words in the previous revision. They represent clarification and amplification that should aid in uniform application of the standard.

This standard might reference documents and other standards that have been superseded or withdrawn at the time the standard is applied. A statement has been included in the references section that provides guidance on the use of references.

This standard does not incorporate the concepts of generating risk-informed insights, performance-based requirements, or a graded approach to quality assurance. The user is advised that one or more of these techniques could enhance the application of this standard.

The working group would like to gratefully acknowledge the contributions by Terry L. Hofer, who died prior to the publication of this revision.

This revision of American National Standard ANSI/ANS-8.1-2014 was prepared by Working Group ANS-8.1 of Subcommittee 8 of the Standards Committee of the American Nuclear Society. Working Group ANS-8.1 had the following membership at the time of the revision:

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Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors

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⁾

2 Scope

This standard is applicable to operations with fissionable materials outside nuclear reactors, except for the assembly of these materials under controlled conditions, such as in critical experiments. Generalized basic criteria are presented, and limits are specified for some single fissionable units of simple shape containing ^{233}U , ^{235}U , or ^{239}Pu , but not for multiunit arrays. Subcritical limits for certain multiunit arrays are contained in ANSI/ANS-8.7-1998 (R2012) [2]. Requirements are stated for validation of any calculational method used in assessing nuclear criticality safety. This standard does not include the details of administrative controls, the design of processes or equipment, the description of instrumentation for process control, nor detailed criteria to be met in transporting fissionable materials. Guidance for transporting light water

reactor (LWR) fuel is contained in ANSI/ANS-8.17-2004 (R2009) [3].

3 Definitions

3.1 Limitations

The definitions given below are of a restricted nature for the purposes of this standard. Other specialized terms are defined in *Glossary of Nuclear Criticality Terms* [4].

3.2 Shall, should, and may

The word “shall” is used to denote a requirement; the word “should” is used to denote a recommendation; and the word “may” is used to denote permission, neither a requirement nor a recommendation.

3.3 Glossary of terms

areal density: The total mass of fissionable material per unit area projected perpendicularly onto a plane. (For an infinite, uniform slab, it is the product of the slab thickness and the density of fissionable material within the slab.)

calculational method: The mathematical procedures, equations, approximations, assumptions, and associated numerical parameters (e.g., cross sections) that yield the calculated results.

controlled parameter: A parameter that is kept within specified limits.

criticality accident: The release of energy as a result of accidental production of a self-sustaining or divergent neutron chain reaction.

effective multiplication factor (k_{eff}): *Physically*, the ratio of the total number of neutrons produced during a time interval (excluding neutrons produced by sources whose strengths are not a function of fission rate) to the

¹⁾ Numbers in brackets refer to corresponding numbers in Sec. 7, “References.”