American Nuclear Society

REAFFIRMED

May 16, 2007
ANSI/ANS-8.1-1998 (R2007)

nuclear criticality safety in operations with fissionable materials outside reactors

an American National Standard

WITHDRAWN

April 15, 2014
ANSI/ANS-8.1-1998;R2007 (W2014)

This standard is no longer being maintained as an American National Standard. This standard may contain outdated material or may have been superseded by another standard. Please contact the ANS Standards Administrator for details.

published by the
American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA

ANSI/ANS-8.1-1998

ERRATUM

ANSI/ANS-8.1-1998 (R2007)
Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors

A typographical error was identified in the heading of the first data column in Table 5 on page 7. The column heading should be $^{233}UO_2$ [2]; not $^{235}UO_2$ [2] as published. The corrected Table 5 is below.

Table 5
Single-Parameter Limits for Oxides Containing No More Than 1.5% Water By Weight at No More Than Half Density [(a)]

Parameter	**$^{233}UO_2$ [2]**	**$^{233}U_3O_8$ [2]**	**$^{233}UO_3$ [2]**	**$^{235}UO_2$ [3]**	**$^{235}U_3O_8$ [3]**	**$^{235}UO_3$ [3]**	**$^{239}PuO_2$ [4]**
Mass of fissile nuclide, kg	23.4	30.5	34.7	88	122	142	27
Mass of oxide, [(b)] kg	27.0	36.6	42.4	102	146	174	30
Cylinder diameter, cm	11.9	14.8	16.3	20.4	26.0	28.8	12.6
Slab thickness, cm	1.6	2.2	2.6	5.8	8.0	9.3	2.8

(a) These are half the maximum bulk densities of Table 4.
(b) These values include the mass of any associated moisture up to the limiting value of 1.5% by weight.

ANSI/ANS-8.1-1998

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

Secretariat
American Nuclear Society

Prepared by the
American Nuclear Society
Standards Committee
Working Group ANS-8.1

Published by the
American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA

Approved September 9, 1998
by the
American National Standards Institute, Inc.

American National Standard

Designation of this document as an American National Standard attests that the principles of openness and due process have been followed in the approval procedure and that a consensus of those directly and materially affected by the standard has been achieved.

This standard was developed under procedures of the Standards Committee of the American Nuclear Society; these procedures are accredited by the American National Standards Institute, Inc., as meeting the criteria for American National Standards. The consensus committee that approved the standard was balanced to ensure that competent, concerned, and varied interests have had an opportunity to participate.

An American National Standard is intended to aid industry, consumers, governmental agencies, and general interest groups. Its use is entirely voluntary. The existence of an American National Standard, in and of itself, does not preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard.

By publication of this standard, the American Nuclear Society does not insure anyone utilizing the standard against liability allegedly arising from or after its use. The content of this standard reflects acceptable practice at the time of its approval and publication. Changes, if any, occurring through developments in the state of the art, may be considered at the time that the standard is subjected to periodic review. It may be reaffirmed, revised, or withdrawn at any time in accordance with established procedures. Users of this standard are cautioned to determine the validity of copies in their possession and to establish that they are of the latest issue.

The American Nuclear Society accepts no responsibility for interpretations of this standard made by any individual or by any ad hoc group of individuals. Requests for interpretation should be sent to the Standards Department at Society Headquarters. Action will be taken to provide appropriate response in accordance with established procedures that ensure consensus on the interpretation.

Comments on this standard are encouraged and should be sent to Society Headquarters.

Published by

American Nuclear Society
555 North Kensington Avenue
La Grange Park, Illinois 60526 USA

Printed in the United States of America

Foreword

(This Foreword is not a part of American National Standard for Criticality Safety in Operations with Fissionable Material Outside Reactors, ANSI/ANS-8.1-1998.)

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 reaffirmed, 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 1975.

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, 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 review and revision of the standard are mostly editorial. Changes in the validation section are explanatory in nature and do not change the intent of the words in the previous revision, but represent clarification and amplification that should aid in uniform application of the standard.

This revision of American National Standard ANS-8.1 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:

A. S. Garcia, Chairman, *U.S. Department of Energy-Idaho*
C. M. Hopper, *Oak Ridge National Laboratory*
R. A. Libby, *Pacific Northwest National Laboratory*
T. P. McLaughlin, *Los Alamos National Laboratory*
J. A. Morman, *Argonne National Laboratory*
D. R. Smith, *Individual*
J. T. Thomas, *Individual*
G. E. Whiteside, *Individual*

The Membership of Subcommittee ANS-8 at the time of this standard's initial vote was:

T. P. McLaughlin, Chairman, *Los Alamos National Laboratory*
J. A. Schlesser, Secretary, *Los Alamos National Laboratory*
F. M. Alcorn, *Babcock & Wilcox Company*
K. E. Bhanot, *British Nuclear Fuels Limited*
E. D. Clayton, *Individual*
D. M. Dawson, *E. R. Johnson, Assoc., Inc.*
A. S. Garcia, *Argonne National Laboratory*
C. M. Hopper, *Oak Ridge National Laboratory*
N. Ketzlach, *Individual*
R. Kiyose, *Tokai University*
R. A. Libby, *Pacific Northwest National Laboratory*
J. F. Mincey, *Oak Ridge National Laboratory*
W. G. Morrison, *Individual*
D. A. Reed, *Martin Marietta Energy Systems, Inc.*
T. A. Reilly, *Westinghouse Savannah River Company*
H. Toffer, *Safe Sites of Colorado, LLC.*
G. E. Whitesides, *Individual*

Consensus Committee N16, Nuclear Criticality Safety, had the following membership at the time of its approval of this standard.

D. R. Smith, Chairman
R. A. Knief, Vice-Chairman

G. H. Bidinger . . . . Individual
R. D. Busch . . . . University of New Mexico
S. P. Congdon . . . . General Electric Company
H. L. Dodds, Jr. . . . . University of Tennessee
R. A. Knief . . . . Ogden Environmental and Energy Services
J. R. LaRiviere . . . . American Institute of Chemical Engineers
C. D. Manning . . . . Siemens Nuclear Power Corporation
S. P. Murray . . . . Health Physics Society
H. C. Paxton . . . . Individual
R. L. Reed . . . . Westinghouse Savannah River Company
B. M. Rothleder . . . . U.S. Department of Energy
F. W. Sanders . . . . Individual
D. R. Smith . . . . Individual
R. G. Taylor . . . . Oak Ridge National Laboratory
J. T. Thomas . . . . Individual
R. M. Westfall . . . . Oak Ridge National Laboratory

Contents

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 non-nuclear 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 must recognize economic considerations, but the protection of operating personnel[1] and the public must be the dominant consideration.

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.[2] Requirements are stated for establishing the validity and areas of applicability 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.[3]

---

[1] Guidance for establishing an alarm system for protection of personnel is contained in American National Standard Criticality Accident Alarm System, ANSI/ANS-8.3-1997.

[2] Limits for certain multiunit arrays are contained in American National Standard Guide for Nuclear Criticality Safety in the Storage of Fissile Materials, ANSI/ANS-8.7-1975 (R1987).

[3] Specific guidance for transporting LWR fuel is contained in American National Standard Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors, ANSI/ANS-8.17-1984 (R1989).

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 Terms in Nuclear Science and Technology*. [1][4]

3.2 Shall, Should, and May. The word “shall” is used to denote a requirement, the word “should” to denote a recommendation, and the word “may” to denote permission, neither a requirement nor a recommendation. To conform with this standard, all operations shall be performed in accordance with its requirements, but not necessarily with its recommendations. When recommendations are not implemented, justification shall be documented.

3.3 Glossary of Terms

area (or areas) of applicability. The limiting ranges of material compositions, geometric arrangements, neutron energy spectra, and other relevant parameters (such as heterogeneity, leakage, interaction, absorption, etc.) within which the bias of a calculational method is established.

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.)

bias. A measure of the systematic differences between calculational method results and experimental data.

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

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

---

[4] Numbers in brackets refer to corresponding numbers in Section 7, References.