

# American Nuclear Society

**REAFFIRMED**

**December 14, 2017**

**ANSI/ANS-8.7-1998 (R2017)**

**February 23, 2012**

**ANSI/ANS-8.7-1998 (R2012)**

**nuclear criticality safety in the  
storage of fissile materials**

## an American National Standard

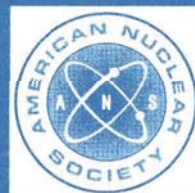
This standard has been reviewed and reaffirmed with the recognition that it may reference other standards and documents that may have been superseded or withdrawn. The requirements of this document will be met by using the version of the standards and documents referenced herein. It is the responsibility of the user to review each of the references and to determine whether the use of the original references or more recent versions is appropriate for the facility. Variations from the standards and documents referenced in this standard should be evaluated and documented.

This standard does not necessarily reflect recent industry initiatives for risk informed decision-making or a graded approach to quality assurance. Users should consider the use of these industry initiatives in the application of this standard.

**REAFFIRMED**

**September 12, 2007**

**ANSI/ANS-8.7-1998  
(R2007)**



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

This is a preview of "ANSI/ANS-8.7-1998 (R...)". [Click here to purchase the full version from the ANSI store.](#)

**ANSI/ANS-8.7-1998**

**American National Standard  
for Nuclear Criticality Safety in  
the Storage of Fissile Materials**

Secretariat  
**American Nuclear Society**

Prepared by the  
**American Nuclear Society  
Standards Committee  
Working Group ANS-8.7**

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

Approved December 2, 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**

Copyright © 1999 by American Nuclear Society. All rights reserved.

Any part of this standard may be quoted. Credit lines should read "Extracted from American National Standard ANSI/ANS-8.7-1998 with permission of the publisher, the American Nuclear Society." Reproduction prohibited under copyright convention unless written permission is granted by the American Nuclear Society.

Printed in the United States of America

## Foreword

(This Foreword is not part of American National Standard for Nuclear Criticality Safety in the Storage of Fissile Materials, ANSI/ANS-8.7-1998.)

As with many standards and guides, the direct solution to a specific problem may not be immediately evident in these pages. The application of some of the mass limits and allowances permitted in storage arrangements requires groups, or individuals, experienced in criticality to examine the contingencies attendant to handling massive pieces, to deviations from established procedures, or to those perturbations or mishaps commonly encountered in storage areas. This standard should be considered not as a substitute for detailed safety analyses, but rather as an integral part of the analysis for the attainment of a sound criticality safety program.

This standard is an extension of American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1998. Attention to details of possible single-unit criticality is, therefore, presumed. The information presented in this standard is primarily directed to criticality safety and is based on validated Monte Carlo calculations. Water is adopted as a standard reflector for storage arrays; because of the variety and thicknesses of concretes that may occur in the more usual conditions of storage, an unambiguous presentation of information is difficult.

This standard provides an orientation and direction to nuclear criticality safety practices. Individual safety groups concerned with specific problems are encouraged to publish solutions to these problems, detailing the bases. Future reviews and revisions of this standard may make use of the information to expand the areas of applicability.

Working Group ANS-8.7 of Subcommittee 8 of the American Nuclear Society Standards Committee was established in November 1967 and prepared a number of drafts of this standard. One draft underwent a one-year trial use and comment period in 1973. This standard was approved by the American National Standards Institute in 1975 as ANSIN16.5-1975 and was reaffirmed in 1987 as ANSI/ANS-8.7-1975 (R1987). This revision includes several textual enhancements and tabulated changes resulting from confirmatory evaluations by Working Group members Kimball and Vessard, and by individuals in industry: Russell L. Bowden of BNFL Consultancy Services, David Hanlon of AEA Technology, E. Fitz Trumble of Westinghouse Savannah River Company, and M. Wesley Waddell of the Oak Ridge Y-12 Plant. These researchers determined that uncertainties associated with the calculated values were larger than previously evaluated. Therefore, this revision includes removal of Table 5.12, Unit Mass Limit in Kilograms of Uranium-233 per Cell in Water-Reflected Storage Arrays, for oxides with H/U  $\leq$  3, 10, and 20, and the removal of limited portions of Tables 5.2, 5.5, and 5.6, Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays, for oxides at 93.2 wt-%, 50 wt-%, and 30 wt-%.

Members of Working Group ANS-8.7 were:

C. M. Hopper, *Chairman, Oak Ridge National Laboratory*  
J. J. Bazley, *Parallax Inc.*  
E. C. Crume, Jr., *Individual*  
K. D. Kimball, *Nisys Corporation*  
B. L. Koponen, *Individual*  
J. S. Philbin, *Sandia National Laboratories*  
J. T. Thomas, *Individual*  
H. Toffer, *Safe Sites of Colorado*  
S. G. Vessard, *Los Alamos National Laboratory*  
D. W. Williams, *Westinghouse Electric Corporation*

This standard was prepared under the direction of Subcommittee 8, Fissionable Materials Outside Reactors, of the Standards Committee of the American Nuclear Society. Members of ANS-8 at the time of draft preparation and approval were:

T. P. McLaughlin, *Chairman, Los Alamos National Laboratory*  
J. A. Schlessler, *Secretary, Los Alamos National Laboratory*  
F. M. Alcorn, *The Babcock & Wilcox Company*  
K. E. Bhanot, *BNFL International Group*  
E. D. Clayton, *Individual*  
D. M. Dawson, *E. R. Johnson Associates, Inc.*  
A. S. Garcia, *Argonne National Laboratory*  
C. M. Hopper, *Oak Ridge National Laboratory*  
N. Ketzlach, *Individual*  
R. Kiyose, *Individual*  
R. A. Libby, *Pacific Northwest National Laboratory*  
J. F. Mincey, *Oak Ridge National Laboratory*  
W. G. Morrison, *Individual*  
D. A. Reed, *Oak Ridge National Laboratory*  
T. A. Reilly, *Westinghouse Savannah River Company*  
H. Toffer, *Safe Sites of Colorado, LLC*  
G. E. Whitesides, *Individual*

Consensus Committee N16, Nuclear Criticality Safety, which reviewed and approved this Standard in 1998, had the following members:

**D. R. Smith, Chairman**  
**R. A. Knief, Co-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

<b>Contents</b>	<b>Section</b>	<b>Page</b>
1. Introduction		1
2. Scope		1
3. Definitions		1
3.1 Limitations		1
3.2 Shall, Should, and May		1
3.3 Glossary of Terms		1
4. Nuclear Criticality Safety Practices		1
4.1 Administrative Practices		1
4.2 Technical Practices		2
5. Parameters, Limits, and Conditions		2
5.1 Unit Mass Limits		3
5.2 Moderation		3
5.3 Position of Unit in Cell		3
5.4 Other Reflectors		3
5.5 Double Batching		3
5.6 Vault Pairs		3
5.7 Reduction Factors		3
5.8 Aisles		4
5.9 Fissile Material Containment and Shelving Materials		4
5.10 Unit Subcriticality		4
5.11 Unit Spacing		4
5.12 Unit Shape		4
6. Other Applications		4
6.1 Commingling of Dissimilar Cells		4
6.2 Interpolation		4
6.3 Noncubic Cells		4
6.4 Position of Unit in Cell		4
6.5 Array Shape		4
6.6 Plutonium-238		4
7. References		4
 <b>Tables</b>		
Table 5.1	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Metal	6
Table 5.2	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Oxides, 93.2 wt-% <sup>235</sup> U, 6.8 wt-% <sup>238</sup> U	7
Table 5.3	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Oxides, 80 wt-% <sup>235</sup> U, 20 wt-% <sup>238</sup> U	8

Table 5.4	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Oxides, 70 wt-% <sup>235</sup> U, 30 wt-% <sup>238</sup> U	9
Table 5.5	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Oxides, 50 wt-% <sup>235</sup> U, 50 wt-% <sup>238</sup> U	10
Table 5.6	Unit Mass Limit in Kilograms of Uranium per Cell in Water-Reflected Storage Arrays: Oxides, 30 wt-% <sup>235</sup> U, 70 wt-% <sup>238</sup> U	11
Table 5.7	Unit Mass Limit in Kilograms of Plutonium per Cell in Water-Reflected Storage Arrays: Metal, 100 wt-% <sup>239</sup> Pu	12
Table 5.8	Unit Mass Limit in Kilograms of Plutonium per Cell in Water-Reflected Storage Arrays: Oxides, 100 wt-% <sup>239</sup> Pu	13
Table 5.9	Unit Mass Limit in Kilograms of Plutonium per Cell in Water-Reflected Storage Arrays: Metal and Oxides, 94.8 wt-% <sup>239</sup> Pu, 5.2 wt-% <sup>240</sup> Pu	14
Table 5.10	Unit Mass Limit in Kilograms of Plutonium per Cell in Water-Reflected Storage Arrays: Metal and Oxides, 80 wt-% <sup>239</sup> Pu, 20 wt-% <sup>240</sup> Pu	15
Table 5.11	Unit Mass Limit in Kilograms of Uranium-233 per Cell in Water-Reflected Storage Arrays	16



# Nuclear Criticality Safety in the Storage of Fissile Materials

## 1. Introduction

Many current storage arrangements for fissile materials, while safe, are wasteful of storage capacity. Experiments with arrays of fissile materials (see References [1] and [2])<sup>1</sup> have provided a means of validating computations, and have demonstrated the safety of mass limits and storage area spacings that are less restrictive than those now in use. This standard is intended to provide general storage criteria based on validated calculations, and includes some engineering and administrative practices appropriate to the storage of fissile material.

The tabulated mass limits presented in this standard are for idealized storage configurations. While these configurations may not be commonly encountered in practice, they do provide bases for establishing safe storage arrays. Because this standard cannot effectively cover all conditions of interest, the use of supplementary information (see References [3], [4], and [5]) is encouraged. For example, subcriticality of arrays not specified in this standard may be confirmed by conducting neutron source multiplication measurements as described in American National Standard for Safety in Conducting Subcritical Neutron Multiplication Measurements In Situ, ANSI/ANS-8.6-1983 (R1995) [6].

## 2. Scope

This standard is applicable to the storage of fissile materials. Mass and spacing limits are tabulated for uranium containing greater than 30 wt-% <sup>235</sup>U, for <sup>238</sup>U, and for plutonium, as metals and oxides. Criteria for the range of application of these limits are provided.

## 3. Definitions

**3.1 Limitations.** The definitions given below are restricted to the purpose of this standard.

**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.

### 3.3 Glossary of Terms

**fissile material.** A material, other than natural uranium, that is capable of sustaining a thermal neutron chain reaction.

**storage unit (unit).** A mass of fissile material considered as an entity. The material may be of any shape, and a unit may consist of separate pieces.

**storage cell (cell).** A volume having defined boundaries within which a storage unit is positioned.

**storage array (array).** A regular arrangement of storage cells.

**validated computational technique.** A calculational technique that has been validated in conformance with American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1998 [7].

## 4. Nuclear Criticality Safety Practices

### 4.1 Administrative Practices

**4.1.1** All operations with fissile material, including storage, shall be conducted in accordance with ANS-8.1 [7]. This standard is intended to supplement ANS-8.1 by providing storage criteria applicable to many fissile materials.

**4.1.2** Methods of storage control and operational practices approved by management shall be described in written procedures. Persons participating in the transfer and storage of material shall be familiar with these procedures. Limits for storage shall be posted.

**4.1.3** Management shall provide for inspections to verify compliance with established procedures.

---

<sup>1</sup> Numbers in brackets refer to corresponding numbers in Section 7, References.