American Nuclear Society

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nuclear criticality control and safety of plutonium-uranium fuel mixtures outside reactors

an American National Standard

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February 11, 2011
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(R2011)
May 6, 2016
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(R2016)

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reviewed and reaffirmed with the recognition that it may reference other standards and documents that may have been superseded or withdrawn.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.

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Revision of
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American National Standard for Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors

Secretariat
American Nuclear Society

Prepared by the
American Nuclear Society
Standards Committee
Working Group ANS-8.12

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by the
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American National Standard

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Foreword

(This Foreword is not a part of American National Standard for Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors, ANSI/ANS-8.12-1987.)

This standard provides guidance for the prevention of criticality accidents in the handling, storing, processing, and transporting of plutonium-uranium fuel mixtures outside reactors and is applicable to all operations involving mixtures of plutonium and natural uranium. It constitutes an extension of the American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1983.

Under the prescribed five year review of ANSI/ANS-8.12-1978, the standard has been revised to include subcritical limits for heterogeneous lattices of mixed oxide fuel pins in water. The basis for the limits for both homogeneous mixtures and for lattices are calculations done by several members of the work group, which have been published in the open literature. These calculations were done by methods that have been validated by correlations with available experimental data, and an adequate margin of subcriticality was allowed. The revised standard was prepared by Work Group ANS-8.12.1 of Subcommittee 8 of the Standards Committee of the American Nuclear Society. This work group was composed of:

E. D. Clayton, Chairman, *Battelle-Pacific Northwest Laboratories*
R. Artigas, *General Electric Company*
C. L. Brown, *Rockwell Hanford Operations*
H. K. Clark, *Savannah River Laboratory*
N. Ketzlach, *U.S. Nuclear Regulatory Commission*
R. Kiyose, *University of Tokyo*
R. A. Libby, *Battelle-Pacific Northwest Laboratory*
D. R. Smith, *Los Alamos National Laboratory*
G. Walker, *U.K. Atomic Energy Authority*

The membership of Subcommittee ANS-8, Fissionable Materials Outside Reactors, at the time of draft preparation and approval was:

J. T. Thomas, Chairman, *Martin Marietta Energy Systems, Inc.*
E. B. Johnson, *Secretary, Oak Ridge National Laboratory*
F. M. Alcorn, *Babcock & Wilcox Company*
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G. E. Whitesides, *Martin Marietta Energy Systems, Inc.*

Consensus Committee N16, Nuclear Criticality Safety, which reviewed and approved this standard in 1987, had the following membership:

Dixon Callihan, Chairman
E. B. Johnson, Secretary

Ricardo Artigas ..... American Society for Testing and Materials (Liaison only)
George H. Bidinger ..... U.S. Nuclear Regulatory Commission
Blake P. Brown ..... U.S. Department of Energy
C. Leslie Brown ..... Institute of Nuclear Materials Management
William T. Mee (Alt.)
Dixon Callihan ..... American Nuclear Society
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John W. Cure, III ..... Health Physics Society
Milton E. McLain, Jr. (Alt.)
Leo E. Hansen ..... Advanced Nuclear Fuels Corporation (formerly Exxon)
J. Robert La Riviere ..... American Institute of Chemical Engineers
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Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors

1. Introduction

The American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1983 [1][1] provides single parameter limits for fissionable units of simple shape containing ^{233}U, ^{235}U, and ^{239}Pu [1]. As an example of multi-parameter control it provides an increase in the limits of ^{235}U resulting from control of the amount of ^{238}U associated with ^{235}U in uranium metal and oxide enriched to no more than 5 wt% ^{235}U. Larger limits for plutonium likewise result from placing reliance on, and hence controlling, the isotopic concentraion of ^{240}Pu and the amount of uranium associated with the plutonium. Such increases may prove valuable for operations with mixed oxides of plutonium and uranium encountered in light water, liquid metal fast breeder, and gas-cooled fast reactor fuel cycle operations.

The limits provided here were calculated (E. D. Clayton [2, 3]) by methods satisfying the requirements for validation of a calculational method as set forth in 4.3 of ANSI/ANS-8.1-1983 [1].

The administrative and technical practices for criticality safety and control as embodied in ANSI/ANS-8.1-1983 [1] and in American National Standard Administrative Practices for Nuclear Criticality Safety, ANSI/ANS-8.19-1984 [4] are applicable herein.

2. Scope

This standard is applicable to operations with plutonium-uranium oxide fuel mixtures outside nuclear reactors, except the assembly of these materials under controlled conditions, such as in critical experiments. Basic criteria are presented for plutonium-uranium fuel mixtures in single units of simple shape containing no more than 30 wt% plutonium combined with uranium containing no more than 0.71 wt% ^{235}U. The limits for uniform aqueous mixtures (solution) are applicable to homogeneous mixtures and slurries in which the particles constituting the mixture are uniformly distributed and have a diameter no larger than 127 μm (0.005 in.), i.e., are capable of being passed through 120 mesh screen.[2]

This standard does not include the details of administrative controls, the design of processes or equipment, the description of instrumentation for process control or detailed criteria to be met in transporting fissionable materials.

3. Definitions

3.1 Limitations. The definitions given below are of a restricted nature for the purpose of this standard. Other specialized terms are defined in H. Alter, et al., "Glossary of Terms in Nuclear Science and Technology" [5].

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. In order to conform with this standard all operations shall be performed in accordance with its requirements but not necessarily with its recommendations.

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

[2]Mixtures containing particles 60-100 μm in size have been considered by experimenters to be homogeneous [V. I. NEELEY and H. E. HANDLER, "Measurement of Multiplication Constant for Slightly Enriched Homogeneous UO_3—Water Mixtures and Minimum Enrichment for Criticality," HW-70310 Hanford Atomic Products Operations (August 1961) and V. I. NEELEY, J. A. BERBERET and R. H. MASTERSON, "k∞ of Three Weight Per Cent ^{235}U Enriched UO_3 and $UO_2(NO_3)_2$ Hydrogeneous Systems," HW-66882, Hanford Atomic Products Operations (September 1961)].