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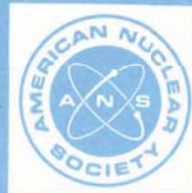
**nuclear criticality safety criteria for
steel-pipe intersections containing
aqueous solutions of fissile material**

WITHDRAWN

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Revision of
ANSI/ANS-8.9-1978

American National Standard
Nuclear Criticality Safety Criteria for Steel-Pipe Intersections
Containing Aqueous Solutions of Fissile Materials

Secretariat
American Nuclear Society

Prepared by the
American Nuclear Society
Standards Committee
Working Group ANS-8.9

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American National Standard

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Foreword (This Foreword is not a part of American National Standard Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials, ANSI/ANS-8.9-1987.)

Basic parameters and practices for nuclear criticality control outside reactors are described in American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1983, and in documents referenced therein. However, for the most part, the data in that standard are single parameter limits.

In the past there has been a paucity of experimental and calculated data for geometric arrangements, such as crosses, ells, and tees, for storage and processing of aqueous solutions of fissile materials in pipes. This situation resulted in overly conservative applications which became evident soon after Work Group 8.9 undertook the drafting of a standard on this subject in 1968. Over the succeeding years, additional experimental data and advanced computational technology became available and now provide the means to reduce the conservatism in industrial practice and permit greater flexibility in process applications. The American National Standard Nuclear Criticality Safety for Pipe Intersections Containing Aqueous Solutions of Enriched Uranyl Nitrate, ANSI/ANS-8.9-1978, has been extended to include typical aqueous solutions of fissile materials and, in particular, uranium containing no more than 5 wt% ^{235}U . Acceptable configurations are presented as standard schedule pipe sizes for a variety of parameters.

In order to facilitate the applicability of this standard allowances have been made for situations which cannot be known or controlled absolutely. The specifications given in this standard are based upon validated calculations in which consideration of an adequate margin of subcriticality included variations in chemical concentrations ($k_{\text{eff}} \sim 0.03$), a bias in calculations of solution systems ($k_{\text{eff}} \sim 0.02$), the influence of container materials ($k_{\text{eff}} \sim 0.05$), and a minimum margin of subcriticality ($k_{\text{eff}} \sim 0.05$). Thus, the systems as specified have a nominal k_{eff} of 0.85. Submerged intersections have a nominal k_{eff} of 0.90. Generally, fissile and other materials will be present in addition to aqueous fissile solutions contained in piping. It will be necessary for a safety specialist to evaluate their reactivity contribution to proposed pipe intersections in order to confirm compliance with requirements of the standard. It would be unusual for a design not to require review by a safety specialist.

This standard was prepared by Work Group ANS-8.9, under the guidance of American Nuclear Society Standards Subcommittee 8. The Work Group, chaired by J. T. Thomas, was comprised of the members of the Subcommittee 8 and J. E. Bigelow, Oak Ridge National Laboratory.

The membership of Subcommittee 8, Fissionable Materials Outside Reactors, at the time of preparation and approval of this revision was:

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Consensus Committee N16, Nuclear Criticality Safety, which reviewed and approved this standard in 1985, had the following membership:

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Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials

1. Introduction

This standard provides criteria and data based on criticality experiments and validated calculations¹⁻⁶ which are generally applicable to homogeneous aqueous solutions of fissile materials. It includes specific information on fissile solutions containing uranium highly enriched in the ²³⁵U or ²³³U isotope, plutonium, and uranium solutions having a ²³⁵U content not exceeding 5 wt% of the total uranium.

2. Scope

This standard is applicable to the storage, transfer, and processing of homogeneous aqueous solutions of uranium and plutonium in intersecting schedule 10, or heavier, steel pipes. No information is included on specific chemical and mechanical technology, on fluid dynamics, or on other engineering fundamentals also required in safe design of process equipment.

3. Definitions

3.1 Limitations. The definitions given below are restricted to the purposes of this standard. Other

¹J. T. Thomas, "Reflectors, Infinite Cylinders, Intersecting Cylinders, and Nuclear Criticality," *Nucl. Sci. Eng.*, **67**, 279 (1978).

²N. F. Cross, G. E. Whitesides, and R. J. Hinton, "Monte Carlo Analysis of Experimentally Critical Pipe Intersections," *Trans. Am. Nucl. Soc.*, **17**, 268 (1973).

³Deanne Dickinson, "Calculations for Pipe Intersections Containing Fissile Solution," RFP-1499, Dow Chemical U.S.A., Rocky Flats Division (1970).

⁴B. B. Ernst and C. L. Schuske, "Empirical Method for Calculating Pipe Intersections Containing Fissile Solutions," RFP-1197, Dow Chemical U.S.A., Rocky Flats Division (1968).

⁵J. K. Fox, L. W. Gilley, and D. Callihan, "Critical Mass Studies, Part IX, Aqueous ²³⁵U Solutions," ORNL-2367, Oak Ridge National Laboratory (1958).

⁶E. B. Johnson, "The Nuclear Criticality of Intersecting Cylinders of Uranyl Fluoride Solutions," Y-DR-129, Oak Ridge Y-12 Plant (1974).

specialized terms are defined in the Glossary of Terms in Nuclear Science and Technology [1].⁷

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

area of intersection. The area of the solution within an arm which intersects a plane tangent to the column at the point where the axis of the arm intersects the surface of the column. (See Fig. 1.)

arm. Any pipe intersecting a column.

column. The pipe of largest diameter in a system of intersecting pipes.

environmental factors. Conditions of the environment, usually not directly related to the process, that may affect the margin of subcriticality of a system and that could be subject to change.

full reflector. A closely fitting, effectively infinite thickness of water, or its equivalent, surrounding the system of pipes.

intermediate reflector. A neutron reflector that contributes reactivity to a column with intersecting arms not exceeding that reactivity corresponding to the presence of a concrete wall in contact with the column and arms in a 2-m-square room having 30-cm-thick concrete walls and floor. (See Fig. 2.)

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