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Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants

an American National Standard

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American National Standard for Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants

Secretariat
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American National Standard

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Foreword

(This Foreword is not a part of American National Standard for Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants, ANSI/ANS-6.4-1997.)

The need for this standard was identified in mid-1972 by D. K. Trubey, then chairman of Subcommittee ANS-6, Radiation Protection and Shielding. The then-existing standard, ANSl N101.6-1972, "Concrete Radiation Shields," provided excellent guidance on the construction of concrete radiation shielding structures, but contained almost no information on shielding effectiveness or analysis. This standard was first issued as ANSI/ANS-6.4-1977 (N403).

After ANSI/ANS-6.4-1977 was issued, two significant events occurred that led to the decision to revise the standard: ANSI N101.6-1972 was withdrawn by ANSI, and the American Concrete Institute (ACI) issued its standard ACI 349-80, "Code Requirements for Nuclear Safety Related Concrete Structures," as well as the Commentary ACI 349R-80, which provided updated requirements with regard to the construction aspects of concrete shielding structures. The withdrawal of ANSI N101.6-1972, the guidance provided by ACI 349-80, and advances in the evolution of shielding methods, data, and applications, led to the revision, ANSI/ANS-6.4-1985.

Since that revision effort, there have been a number of other advances, particularly with respect to buildup factors. These advances have prompted this newest revision, ANSI/ANS-6.4-1997.

This revised standard is meant to be a "guide to good practice" in the area of concrete shielding analysis and design. Recommendations are given where possible, but more often the choice of analytical methods must be left to the discretion of the shielding engineer as appropriate to the particular job, whether it be a conceptual design or final construction drawing.

This standard was revised by Working Group ANS-6.4 of the American Nuclear Society, which had the following members at the time it prepared and approved this standard:

J. L. Kamphouse, Chairman, *Tennessee Valley Authority*
R. J. Donahue, *Lawrence Berkeley National Laboratory*
S. J. Haynes, *Washington Public Power Supply System*
A. R. Larson, *Bechtel Corporation*
R. W. Roussin, *Oak Ridge National Laboratory*
J. K. Warkentin, *TU Electric Company*

Subcommittee ANS-6, Radiation Protection and Shielding, had the following membership at the time of its approval of this standard:

W. C. Hopkins, Chairman, *Bechtel Corporation*
D. R. Harris, Jr., *Rensselaer Polytechnic Institute*
J. L. Kamphouse, *Tennessee Valley Authority*
D. C. Kaul, *Science Applications International Corporation*
R. T. Klann, *Argonne National Laboratory-West*
D. K. Trubey, *Individual*
N. Tsoulfanidis, *University of Missouri-Rolla*

Consensus Committee N-17, Research Reactors, Reactor Physics, Radiation Shielding, and Computational Methods, had the following membership at the time it reviewed and approved this standard:

T. M. Raby, Chairman
A. Weitzberg, Secretary

H. Alter	U. S. Department of Energy
A. D. Callihan	Individual
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W. L. Whittemore	GA Technologies, Inc.

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Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants

1. Scope

This standard contains methods and data needed to calculate the concrete thickness required for radiation shielding in nuclear power plants. Where possible, specific recommendations are made regarding radiation attenuation calculations, shielding design, and standards of documentation. The standard provides guidance to architect-engineers, utilities, and reactor vendors who are responsible for the shielding design of stationary nuclear plants. This standard does not consider sources of radiation other than those associated with nuclear power plants. It also excludes considerations of economic aspects of shielding design.

Concrete is a mixture of materials, the exact proportions of which will differ from application to application. This standard includes a discussion of the nature of concrete, emphasizing those variable aspects of the material which are important to the shield designer. The document discusses methods of analysis and the shielding input data appropriate to each method. Applications of the analytical methods are given, including bulk transport, radiation heating, streaming, and reflection problems.

2. Requirements and Recommendations

2.1 Conformance. The world "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 concrete shield analyses and designs shall be performed in accordance with its requirements, but not necessarily with its recommendations.

2.2 Requirements

2.2.1 Calculational Methods. Any applicable method may be used by the designer in the analysis of shield effectiveness. The designer shall be aware, however, of any limitations imposed by the method employed. Approximations shall be chosen such that the attenuation afforded by the concrete shield is known to be conservative with respect to the design objective. Conservatism may also be introduced by other means, such as the source strength used or the radiation design dose rate outside the shield; the concrete shield analysis need not necessarily be inherently conservative.

2.2.2 Data. Selection of material composition, density, cross sections, albedos, or other properties shall be made such that calculational results are conservative with respect to the design objectives as measured by attenuation afforded by the shield.

2.2.3 Operational Environment. Nuclear heating shall be considered during the determination of the operating temperature and water content of a concrete primary reactor shield, and of any other concrete shields which are exposed to an incident energy flux greater than 10^{10} MeV/cm^2-sec and which will operate at a temperature of 65 °C or greater.

2.2.4 Penetrations. All penetration configurations in concrete shield walls shall be shown to provide adequate attenuation. This requirement shall be satisfied by one of the following:

(1) Analysis that follows the guidance of 8.4 of this standard.
(2) Determination that the configuration is similar to one which is functioning properly under comparable conditions in an operating nuclear facility.
(3) Determination that the configuration is similar to one which has been evaluated experimentally and found to be effective for the radiation levels under consideration.
(4) Determination that the configuration is similar to one which has already been shown by analysis to be effective.