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specification for radiation shielding materials

an American National Standard

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Foreword

(This Foreword is not a part of American National Standard Specification for Radiation Shielding Materials, ANSI/ANS-6.4.2-1985.)

The need for this standard was identified in mid-1977 by the Working Group ANS-6.4. At that time, it was recognized that an increasing number of different material/design shielding concepts were being introduced into nuclear power plants to solve neutron and gamma-ray streaming problems. For protection against neutron streaming, materials varying from water-filled rubber bags, rubber balls, special concretes, treated plastics and silicone gels were proposed, while lead-filled silicone rubber and gels were proposed for gamma-ray streaming. With such a variety of materials, some only a year or two after initial commercial introduction, a clear need was discerned to standardize the specification of these materials to assist the material manufacturer in the type of information he needs to provide to the user.

The focus of the working group's initial work was to orient the standard toward the reporting requirements used by material suppliers rather than toward the preparation of specifications by designers and end users. This focus has been maintained through the development of this standard as that representing the true needs of nuclear power plants in this area.

Working Group 6.4.2 of the American Nuclear Society Standards Committee had the following membership:

E. Normand, Chairman, *Boeing Aerospace Company*
J. S. Brtis, *Sargent & Lundy*
W. L. Bunch, *Hanford Engineering Development Laboratory*
B. A. Engholm, *GA Technologies*
J.L. Kamphouse, *Gilbert/Commonwealth, Inc.*
N. B. Willoughby, *Consultant*

At the time of approval of the standard, Subcommittee ANS-6, Radiation Protection and Shielding, of the American Nuclear Society Standards Committee had the following membership:

D.K. Trubey, Chairman, *Oak Ridge National Laboratory*
E. T. Boulette, *Maine Yankee Atomic Power Company*
J. C. Celnik, *Stone & Webster Engineering Corporation*
D. R. Harris, *Rensselaer Polytechnic Institute*
W. C. Hopkins, *Bechtel Corporation*
E. Normand, *Boeing Aerospace Company*
P. J. Persiani, *Argonne National Laboratory*
D. J. Schuh, II, *GEB Controls Group, Inc.*

The American National Standards Committee N17, Research Reactors, Reactor Physics, and Radiation Shielding, had the following membership at the time it reviewed and approved this standard:

R. S. Carter, Chairman
T. M. Raby, Secretary

Organization Represented	*Name of Representative*
American College of Radiology	M. M. Ter Pogossian
American Institute of Chemical Engineers	D. Duffey
American Nuclear Society	R. S. Carter
American Physical Society	W. W. Havens
	H. Goldstein (Alt.)
American Public Health Associations	W. A. Holt (Alt.)
Health Physics Society	J. D. Buchanan
National Bureau of Standards	T. M. Raby
National Council on Radiation Protection and Measurements	A. B. Chilton
U.S. Department of Energy	P. B. Hemmig
	J.W. Lewellen (Alt.)
U.S. Nuclear Regulatory Commission	R. E. Carter
Individual Members	J.E. Olhoeft
	E. A. Warman
	W. L. Whittemore

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Contents

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Specification for Radiation Shielding Materials

1. Scope

This standard sets forth physical and nuclear properties that shall be reported by the supplier as appropriate for a particular application in order to form the basis for the selection of radiation shielding materials.

2. Conformance

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, materials that are to be considered for use as a radiation shield shall be evaluated against the physical and nuclear properties that the standard sets forth. Accuracy of the determined values shall be provided. Unless otherwise specified, it will be assumed that all values are at a pressure of one atmosphere. Units used in specifying properties shall be in the SI system as specified in this standard, but may be expressed in other convenient units as well.

3. Terms and Definitions

The following terms and definitions are provided to assure uniform understanding of the selected terms as are used in this standard. A large number of additional terms that are used are defined in the following documents: Standard Definition of Terms Relating to Methods of Mechanical Testing, ASTM E6, [1][1] Standard Definitions of Terms Relating to Density and Specific Gravity of Solids, Liquids and Gases, ASTM E12 [2]; Standard Terminology Relating to Fire Standards, ASTM E176 [3]; Standard Definition of Terms Relating to Rubber, ASTM D1566 [4]; Cement and Concrete Terminology, ACI 116R [5]; and American National Standard Glossary of Terms in Nuclear Science and Technology, ANSI N1.1-1976/ANS-9 [6].

Arrhenius model. A model commonly used in accelerated aging tests that relates the rate of reaction of a material to temperature by a simple exponential function, $r = A \exp(-\Phi/kT)$, where r is the reaction rate, A is a material constant (frequency factor), Φ is the activation energy of the material (ev), k is Boltzmann's constant (0.8617×10^{-4} ev/°K) and T is absolute temperature (°K)

bremsstrahlung. Gamma radiation emitted by an electron when it is deflected by the Coulomb field of an atomic nucleus of charge Z; the fraction of energy radiated as photons by an electron of initial energy E (Mev) is approximated numerically by ZE/1000.

equivalent test. A test method utilized in place of a standard or reference test which achieves the same end result.

induced radioactivity. Radioactivity due to the interaction of an external neutron radiation field with the nuclides of a material.

operating range. The range of values over which a parameter, indicative of environmental conditions, is stated to vary during the expected life of a material as it performs its intended function.

photoneutron. Neutron released from an atomic nucleus in a photonuclear reaction with a gamma ray of sufficiently high energy. The threshold energy required of the gamma ray is approximately 2 Mev for beryllium and deuterium, but greater than 8 Mev for other elements.

specific gravity. For purposes of this standard, specific gravity is considered numerically equal to density.

trace element. An element found in small quantities (usually less than 1%) within a material.

trace radioactivity. Radioactivity due to trace amounts of naturally occurring radioisotopes contained within a material.

4. Introduction and General Description.

4.1 Introduction. The properties discussed in this standard are considered to be the most important ones for radiation shielding materials

[1]Numbers in brackets refer to corresponding numbers in Section 8, References.