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Fast-Neutron Removal Characteristics for a Glass Composition

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Abstract: As the neutron is more dangerous than other radiation, the attenuation of fast neutrons is an important consideration in radiation-protection systems used in nuclear facilities, research laboratories, medical applications involving neutron sources, and industrial environments. This study presents a focused theoretical assessment of the fast-neutron removal characteristics reported for a nominal $40MgO–22.5B_2O_3–30SiO_2–7.5La_2O_3$ (mol%) glass composition. The source dataset reports a material density of 3.14 g cm^{-3} and a fast-neutron removal cross section of 0.076747 cm^{-1}. Using the exponential removal approximation, characteristic lengths were derived from this reported coefficient: a mean free path of 13.03 cm, a half-value thickness of 9.03 cm, and a tenth-value thickness of 30.00 cm.

1. Introduction

The attenuation of fast neutrons is an important consideration in radiation-protection systems used in nuclear facilities, research laboratories, medical applications involving neutron sources, and industrial environments. Unlike photons, fast neutrons are uncharged particles and interact with matter predominantly through nuclear interactions. Their transport and attenuation therefore depend on the neutron energy distribution and on the elemental composition and density of the shielding medium [1,2].Glass-based materials are of interest for radiation protection because their chemical composition can be adjusted to incorporate elements with different nuclear interaction characteristics. Borate- and silicate-containing glass systems are particularly relevant as candidate matrices; however, the shielding performance of any specific formulation must be evaluated using neutron-appropriate parameters and validated for the neutron spectrum of interest.One commonly used descriptor for fast-neutron shielding is the fast-neutron removal cross section, often expressed as a macroscopic removal coefficient with units of inverse length. Within a simplified exponential-removal model, this parameter characterizes the reduction in the uncollided or effectively transmitted fast-neutron component as shielding thickness increases. It is not, by itself, a complete description of neutron transport, energy moderation, capture, or secondary radiation.The present work isolates the neutron-related information in the supplied manuscript dataset and excludes all photon attenuation, effective atomic number, and photon buildup-factor results. The objective is to report and interpret the available fast-neutron removal coefficient for the nominal $MgO–B_2O_3–SiO_2–La_2O_3$ glass composition without extending the dataset beyond what it supports.

2. Materials and Methods

The source worksheet identifies the nominal composition as $40MgO–22.5B_2O_3–30SiO_2–7.5La_2O_3$ (mol%) and reports a density of 3.14 g cm^{-3}. The only neutron-specific numerical result available in the supplied manuscript is a fast-neutron removal cross section of 0.076747 cm^{-1}. No neutron energy spectrum, energy-dependent removal data, neutron flux measurements, sample preparation details, or explicit computational settings are provided.
The source manuscript also documents an inconsistency between the nominal molar formulation and the compound weight fractions listed in its worksheet. In particular, Al_2O_3 and Y_2O_3 have zero nominal molar fractions but non-zero listed weight fractions. Because the exact composition used in the neutron calculation cannot be confirmed from the supplied information, the reported coefficient is retained as a

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source-reported value and is not represented as an independently reproduced calculation for a verified glass formulation.

For a first-order description, the attenuation of the fast-neutron component may be represented by an exponential removal relation:

$$I(x) = I_0 \exp(-\Sigma_r x) \quad (1)$$

where I_0 is the incident fast-neutron intensity or fluence rate, I(x) is the corresponding transmitted component after traversing a thickness x, and Σ_r is the macroscopic fast-neutron removal coefficient (cm^{-1}). In this simplified representation, the characteristic removal length is:

$$\lambda_r = 1/\Sigma_r \quad (2)$$

The thicknesses corresponding to 50% and 10% transmission in the exponential approximation are:

$$x_{1/2} = \ln(2)/\Sigma_r; \qquad x_{1/10} = \ln(10)/\Sigma_r \quad (3)$$

These characteristic thicknesses are derived mathematically from the reported removal coefficient. They are not separate measured values, nor do they replace a full neutron-transport calculation that accounts for energy-dependent scattering, moderation, absorption, and secondary particle production.The analysis is descriptive. The reported neutron-removal coefficient was used to calculate the characteristic removal length, half-value thickness, and tenth-value thickness using Eqs. (2) and (3). No statistical analysis was performed because only one calculated neutron parameter was available. No independent Monte Carlo simulation, experimental measurement, or comparison with a reference neutron spectrum was undertaken.

3. Results and Discussion

The supplied dataset gives a fast-neutron removal cross section of 0.076747 cm^{-1} for the material identified in the worksheet, with a reported density of 3.14 g cm^{-3}. The coefficient is a macroscopic quantity: its inverse-length unit indicates that it describes neutron removal in relation to material thickness. A larger macroscopic removal coefficient would, under otherwise comparable conditions and within the same model assumptions, correspond to a shorter characteristic removal length.

Table 1. *Source-reported neutron parameter and characteristic thicknesses derived using the exponential-removal approximation.*

Parameter	Value
Nominal composition	$40MgO–22.5B_2O_3–30SiO_2–7.5La_2O_3$ (mol%)
Reported density	3.14 g cm^{-3}
Fast-neutron removal coefficient, Σ_r	0.076747 cm^{-1}
Derived characteristic removal length, $1/\Sigma_r$	13.03 cm
Derived half-value thickness, $\ln(2)/\Sigma_r$	9.03 cm
Derived tenth-value thickness, $\ln(10)/\Sigma_r$	30.00 cm

Substitution of the reported coefficient into Eq. (2) gives a characteristic removal length of approximately 13.03 cm. The corresponding half-value thickness is approximately 9.03 cm, while the tenth-value thickness is approximately 30.00 cm. Under the idealized exponential model, these values represent the thicknesses associated with reductions of the modeled transmitted fast-neutron component to one-half and one-tenth of its initial value, respectively.

The derived thicknesses offer an accessible interpretation of the reported macroscopic coefficient. Nevertheless, they should be treated as model-based descriptors rather than design-ready shielding thicknesses. Actual neutron dose reduction behind a shield can differ because scattered neutrons may contribute to the transmitted field, and neutron energy changes as particles undergo elastic and inelastic scattering and absorption. The incident spectrum, geometry, surrounding materials, and detector response are therefore essential to a realistic shielding assessment [2].

The neutron-related evidence in the supplied file is limited to a single fast-neutron removal coefficient. No energy-dependent values or neutron spectra are available, and the procedure used to obtain the

coefficient is not documented. It is consequently not possible to determine whether the value corresponds to a particular reference spectrum, to compare performance across neutron energies, or to establish the response under a defined irradiation geometry.A further limitation concerns the composition record. The worksheet reports non-zero weight fractions for Al_2O_3 and Y_2O_3 even though their nominal molar fractions are zero. This discrepancy may affect the elemental composition used in the underlying calculation. The reported coefficient should therefore not be attributed conclusively to the nominal glass formulation until the composition table and computational inputs have been reconciled.For a stronger neutron-shielding study, the composition should first be verified and the removal coefficient recalculated from documented elemental fractions and an identified neutron spectrum or evaluated data source. The analysis should then be complemented by energy-dependent neutron transport calculations (for example, a suitably configured Monte Carlo simulation) and, where feasible, experimental transmission or dose measurements. Reporting neutron flux and dose-equivalent responses as functions of shield thickness would provide a more complete assessment. As this topicpopular there are many different Works done and reported on the litrature[3-19].

4. Conclusions

This neutron-focused analysis extracted the fast-neutron result from the supplied manuscript and removed all photon-related data and discussion. The source dataset reports a fast-neutron removal coefficient of 0.076747 cm^{-1} for a nominal $40MgO–22.5B_2O_3–30SiO_2–7.5La_2O_3$ glass composition with a stated density of 3.14 g cm^{-3}. Based on the exponential-removal approximation, the coefficient corresponds to a derived characteristic removal length of 13.03 cm, a half-value thickness of 9.03 cm, and a tenth-value thickness of 30.00 cm.These results provide only a preliminary, single-parameter indication of fast-neutron removal. The absence of neutron-spectrum information, computational details, and independent validation prevents a broad claim regarding neutron-shielding effectiveness. In addition, the inconsistency in the source composition table must be resolved before the coefficient can be confidently assigned to the nominal glass formulation. Future work should verify the composition, document the neutron spectrum and calculation methodology, and validate the predicted response using neutron-transport simulations and/or experiments.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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