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CALCULATION OF BUILDUP FACTORS USING TAYLOR'S APPROXIMATION FOR MULTI-LAYERED SHIELDS

Shielding is a fundamental component of radiation protection, providing a dependable method to limit personnel exposure by reducing dose rates through attenuation of radiation[1]. The buildup factor is essential in broad-beam geometry scenarios, where scattered radiation contributes significantly to the detected radiation dose, complicating the shielding analysis.
Taylor's approximation offers a methodical approach to estimate the buildup factors for multi-material shields[2]. By expressing the buildup factor as a series expansion, this method allows for the calculation of buildup factors for each layer of the shield individually, and subsequently combining them to obtain the overall buildup factor for the entire shield. This layered approach is especially useful for complex shielding configurations involving different materials and thicknesses.
An example calculation is provided to demonstrate the practical application of Taylor's approximation in a two-layered shield scenario. The first layer consists of Material A with a thickness of 2 cm and a fitting parameter $k_1 = 0.5$, while the second layer consists of Material B with a thickness of 3 cm and a fitting parameter $k_2 = 0.3$. Using Taylor's series expansion up to the second order, the buildup factors for each layer are calculated and combined, resulting in a total buildup factor of approximately 5.76. This example highlights the utility of Taylor's approximation in accurately determining buildup factors for complex, multi-material radiation shields.
This method is particularly beneficial for designing and optimizing radiation shielding in various applications, including medical radiology, industrial radiography, and nuclear research. By providing a clear and systematic approach to calculate buildup factors, Taylor's approximation aids in ensuring effective radiation protection and safety[3].
Radiation shielding is a critical aspect of radiation protection, aiming to limit the exposure of personnel and the environment to harmful ionizing radiation. The effectiveness of shielding depends on various factors, including the type and energy of the radiation, the properties of the shielding materials, and the geometry of the radiation source and shield. In practical scenarios, radiation often follows a broad-beam geometry, where scattered radiation significantly contributes to the detected dose. To account for this, the concept of the buildup factor is introduced, which corrects the simple exponential attenuation law to include the effects of scattered radiation.
Taylor's approximation method provides a systematic approach to estimate the buildup factors for multi-layered shields. The buildup factor $B(E,x)$ at photon energy E and shield thickness x is represented as a series expansion:
$B(E,x) = 1 + \sum_{n=1}^{N} \frac{(k \cdot n)^n}{n!}$
where k is a fitting parameter specific to the material and photon energy, and N is the order of the approximation. For multi-layered shields, the buildup factor for each layer is calculated individually and then combined to obtain the overall buildup factor.
Taylor's approximation provides a practical and effective method for calculating buildup factors in multi-layered radiation shields. By considering the contributions of each layer individually and combining them, this method allows for accurate determination of the overall buildup factor, essential for effective radiation protection. The example calculation demonstrates the utility of this approach in real-world scenarios, offering a valuable tool for designing and optimizing radiation shielding across various applications.
References

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Section

Radiation ecology and methods of analysis (Section 3)

Primary authors: TUYMURADOV, Abror (National University of Uzbekistan); TUYMURODOV, Dilmurod

(National University of Uzbekistan); Prof. PALVANOV, Satimboy (National University of Uzbekistan); ASHUROV, Sindorjon (National University of Uzbekistan)

Presenter: ASHUROV, Sindorjon (National University of Uzbekistan)

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