Distance- and Direction-Dependent Dose Responses of a Portable G-M Detector for Sealed ^{60}Co and ^{22}Na Sources

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Introduction & Motivation

1. Clear Front–Rear Asymmetry in Detector Response

2. Directional Dependence with Changes in Azimuthal Angle

3. Influence of Source–Detector Positioning on Measured Dose Response

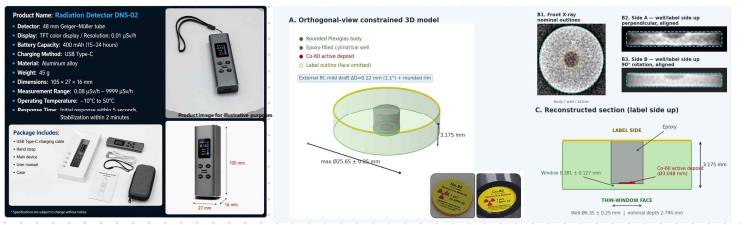
4. Nonlinear Decrease in Response with Source-to-Detector Distance

5. Practical Detection Range for Low-Activity Sealed Sources

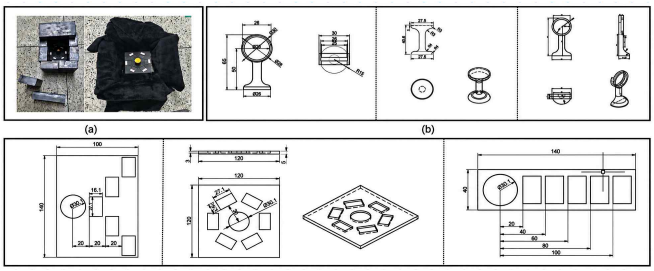
6. Need for Standardization of Portable G-M Detector Measurement Conditions

Summary:
The readings of a portable G-M detector are not determined solely by source activity or gamma-ray energy, but can be significantly influenced by **detector orientation, measurement geometry, source-to-detector distance, radionuclide-specific photon emission characteristics, and direction-dependent attenuation associated with sealed-source encapsulation**. Therefore, both **detector- and source-related geometrical effects, including source orientation and encapsulation**, should be experimentally characterized and considered in quantitative radiation measurements.

Experimental Instruments and Materials

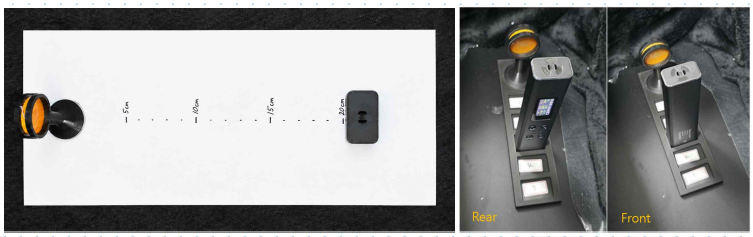


< Portable G-M Detector and Sealed Radioactive Sources >



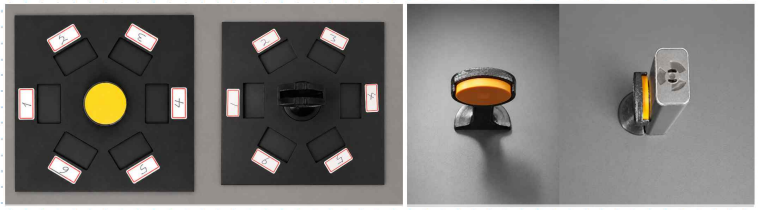
< Experimental shielding arrangement and custom-fabricated source positioning system >

Experimental Method



(a) (b)

< (a) Experimental geometry for distance-dependent dose-rate measurements using the DNS-02 detector. (b) Measurement configurations for evaluating the front- and rear-side response of the DNS-02 detector at source-to-detector distances of 2, 4, 6, 8, and 10 cm. >



(c) (d)

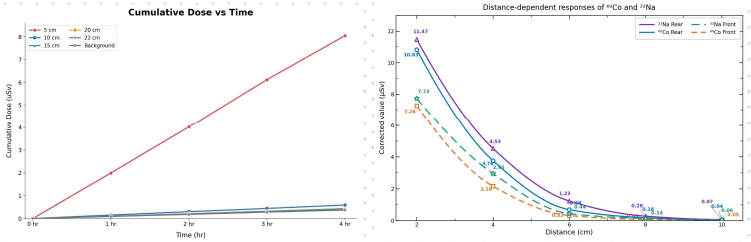
< (c) Experimental configurations for evaluating the directional dependence of the DNS-02 detector. (d) Experimental setup for direct-contact measurement. >



(e) (f)

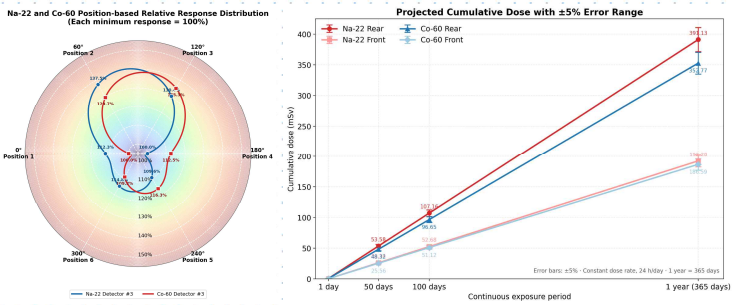
< (e) Fan-shaped measurement configuration. (f) DNS-02 detector rotation. >

Results



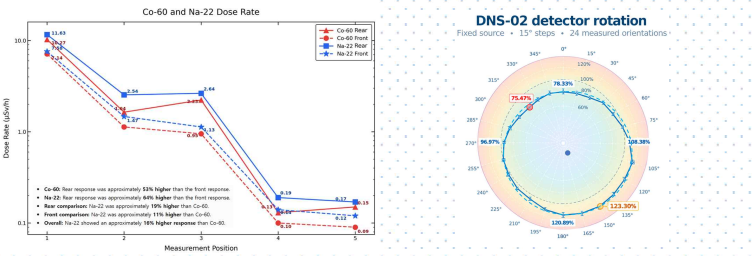
(a) (b)

< (a) The cumulative dose increased linearly with measurement time, while dose accumulation decreased significantly with increasing source-to-detector distance. (b) Both ^{60}Co and ^{22}Na exhibited nonlinear distance-dependent responses in the accumulated dose over 1 h, with generally higher doses in the rear orientation than in the front orientation. >



(c) (d)

< (c) Both ^{60}Co and ^{22}Na exhibited nonuniform, asymmetric angular response distributions across six measurement positions, demonstrating the influence of relative source-to-detector geometry on the measured response. (d) Under the assumption of constant dose rates and continuous exposure (24 h/day), the projected cumulative dose increased linearly with time. These hypothetical projections do not account for radioactive decay. >



(e) (f)

< (e) Both ^{60}Co and ^{22}Na showed position-dependent variations in dose rates, with consistently higher responses in the rear orientation than in the front orientation. (f) Detector rotation at 15° intervals revealed asymmetric angular responses ranging from 75.47% to 123.30% of the mean response, demonstrating pronounced directional dependence. >

Summary

1. This study quantitatively evaluated the dose-rate response characteristics of the portable G-M detector (DNS-02) using sealed ^{60}Co and ^{22}Na radioactive sources, focusing on source-to-detector distance, angular orientation, and experimental geometry.

2. The measured dose rates decreased nonlinearly with increasing source-to-detector distance, while variations in source geometry and the effective detection position significantly influenced the detector response, particularly at short distances.

3. Comparative measurements of the front and rear detector orientations revealed pronounced directional asymmetry, with generally higher dose-rate responses observed in the rear-facing configuration for both radioactive sources, particularly at shorter distances.

4. Angular rotation measurements demonstrated nonuniform and asymmetric response distributions, indicating that detector orientation and incident radiation direction substantially influence the measured dose-rate response.

5. These findings emphasize the importance of considering source-to-detector distance, detector orientation, radionuclide characteristics, and measurement geometry to improve the reliability and accuracy of portable G-M detector measurements and establish standardized radiation monitoring procedures.

References

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