

Standard Operating Procedure: Gamma-Ray Soil Moisture Scanner Calibration & Safety

Sensor System: Gamma-Ray Soil Moisture & Density Attenuation Scanner | Doc Ref: SOP-GAMMA-RAY-SO-2026

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1. Purpose & Scope

This Standard Operating Procedure (SOP) defines field radiation safety, detector energy window calibration, and attenuation measurement protocols for gamma-ray soil moisture scanners. Gamma-ray scanners measure soil bulk density and volumetric water content (VWC) in real time by evaluating non-destructive beam attenuation through soil layers up to 2.5 cm thick.

2. Equipment & Reference Standards

- Gamma-Ray Scanner Assembly:** Cs-137 (662 keV) or Am-241 (59.5 keV) sealed radioactive source collimator with NaI(Tl) scintillation detector tube.
- Multichannel Analyzer (MCA):** Portable gamma-ray spectrometer with high-voltage bias supply (600–1200 V DC).
- Calibration Absorber Plates:** High-purity aluminum and acrylic calibration attenuator plates of known mass thickness.
- Radiation Safety Kit:** Survey meter, film badge/dosimeter, and lead-lined transport container.

3. Radiation Safety & Pre-Field Audit

Verify radiation license compliance, transport container locks, and survey meter operation. Measure background exposure at 1.0 m ($<0.05\text{ mR/hr}$). Confirm collimator shutter operates smoothly and locks in the CLOSED position when not actively taking measurements.

4. Calibration & Attenuation Measurement Procedure

- Photopeak Energy Window Alignment:** Power MCA and set HV bias to 950 V. Adjust gain to center the Cs-137 photopeak at channel 662 (662 keV). Set upper and lower level pulse-height discriminators around the photopeak ($600\text{--}720\text{ keV}$).
- Air Beam Count Rate (I_0):** Mount source and detector on the rigid calibration frame across a 10 cm air gap with shutter OPEN. Record unattenuated count rate I_0 over 300 seconds ($I_0 \geq 10,000\text{ cps}$, relative error $<0.3\%$).
- Standard Absorber Verification:** Insert the 1.0 cm aluminum reference plate. Verify attenuated count rate I_{alum} follows Beer-Lambert attenuation law $I = I_0 e^{-\mu x}$.
- In-Situ Soil Attenuation:** Position collimator arms on opposite sides of undisturbed 2.5 cm soil core. Record attenuated count rate I . Calculate soil wet bulk density and convert to VWC using dry soil attenuation coefficients.

5. Quality Control & Record Keeping

Log background radiation, I_0 air count rate, battery voltage, and dead-time percentage ($<5.0\%$). Document all safety checks in the Field Radiation Logbook.

FIELD SPECIALIST APPROVAL	DOCUMENT CONTROL STAMP
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