

HP SURVEY INSTRUMENT CALIBRATION AND SELECTION

PRINCIPLES OF RADIATION DETECTION AND QUANTIFICATION CHAPTER 5

January 13 – 15, 2016

TECHNICAL MANAGEMENT SERVICES



Canadian Nuclear
Laboratories

Laboratoires Nucléaires
Canadiens

CHAPTER 5 - REVIEW AND SUMMARY

ALMOST EVERY TYPE OF RADIATION
DETECTOR RESPONDS TO ALMOST
EVERY TYPE OF RADIATION

POTENTIAL IMPROVEMENTS

WEBSITES

ALMOST EVERY TYPE OF RADIATION DETECTOR RESPONDS TO ALMOST EVERY TYPE OF RADIATION

Gas Filled Radiation Detectors

Ionization Detectors

Gamma

Beta (with a beta window)

Alpha (with a window $< \sim 10 \text{ mg/cm}^2$)

Neutron (Fast neutrons above $\sim 150 \text{ KeV}$)

Gas Proportional Detectors

Gamma

Beta (with a shell $< \sim 500 \text{ mg/cm}^2$)

Alpha (with a window $< \sim 10 \text{ mg/cm}^2$)

Neutron (Fast neutrons above $\sim 150 \text{ KeV}$)

Geiger-Muller Detectors

Gamma

Beta (with a shell $< \sim 500 \text{ mg/cm}^2$)

Alpha (with a window $< \sim 10 \text{ mg/cm}^2$)

Neutron (Fast neutrons above $\sim 150 \text{ KeV}$)

Half-value Thickness vs Beta Energy

Isotope	E_{\max} (MeV)	Half-Value Thickness mg / cm ²
C-14	0.156	2
Tc-99	0.292	7.5
Cl-36	0.714	15
Sr/Y-90	0.546 / 2.284	150
U-238 Betas from short lived progeny	0.191 / 2.281	130
P-32	1.710	150

Estimate the half-value thickness for a beta emitter.

$$\text{mg/cm}^2 = 50 \times E^2$$

where E is E_{\max} in MeV for the beta emitter

This equation tends to underestimate the half-value thickness for low energy betas and overestimate the half-value thickness for high energy betas.

Path Length for Alphas vs Alpha Energy

Alpha particles lose about 0.8 MeV per mg/cm^2 density thickness of the attenuating material.

Therefore a gas proportional Gas-Proportional or GM detector with a window thickness of $2 \text{ mg}/\text{cm}^2$ will not detect alpha emitters of less than 4 MeV energy.

Alpha particle energy transfer to air

6 MeV alpha particles produce 40,000 Ion Pairs per cm

4 MeV alpha particles produce 55,000 Ion Pairs per cm

w for air is 34 eV per Ion Pair

therefore;

6 MeV alpha particles lose 1.18 MeV per cm of air

4 MeV alpha particles lose 1.87 MeV per cm of air

Alpha particle range in cm of air at 1 atmosphere

$$R = 0.56 E \quad (E < 4 \text{ MeV})$$

$$R = 1.24 E - 2.62 \quad (E > 4 \text{ MeV})$$

Alpha particles lose about 60 KeV of energy per mm of air at STP.

Scintillation Detectors

ZnS Alpha Detectors

Gamma (PMT response to gammas)₂

Alpha (typical window $< \sim 0.8 \text{ mg/cm}^2$)

Neutron (Fast neutrons above $\sim 150 \text{ KeV}$ due to proton recoil in the ZnS support)

ZnS/plastic scintillator alpha/beta Detectors

Gamma (PMT and plastic scintillator responses to gammas)

Beta in the alpha channel (threshold setting)

Alpha in the beta channel (threshold setting)

Neutron (Fast neutrons above $\sim 150 \text{ KeV}$ due to proton recoil in the plastic scintillator)

NaI and other scintillators

Gamma

Beta (with a window $< \sim 500 \text{ mg/cm}^2$)

PMTs and Photodiode Detectors

Gamma (PMT and photodiode response to gammas)

Semiconductor Detectors

Alpha Detectors

Beta (above ~ 1 MeV)

Alpha/Beta Detectors

Gamma (in the beta channel)

Beta in the alpha channel (threshold setting)

Alpha in the beta channel (threshold setting)

Neutron Detectors

BF_3 and He^3 Detectors

Gamma (Threshold and/or HV Setting)

Plastic scintillator Detectors

Gamma (plastic scintillator and PMT responses to gammas)

Organic scintillator Detectors

Gamma response in the organic scintillator

SOME POTENTIAL IMPROVEMENTS

BETTER TRAINING

BETTER COMMUNICATIONS

LIGHTER INSTRUMENTS

SMARTER INSTRUMENTS WITH SIMPLE DISPLAYS

INSTRUMENTS WITH LESS EXTERNAL INTERFERENCE

INSTRUMENTS WITH LESS CROSSTALK

WEBSITES

HPS.ORG List of Affiliates

Ameriphysics, LLC

Arrow-Tech, Inc.

Berkeley Nucleonics

Best Dosimetry Services

Bionomics, Inc.

Bladewerx LLC

Canberra Industries

Chase Environmental Group

Chesapeake Nuclear Services, Inc.

Curie Environmental Services

Dade Moeller & Associates, Inc.

DATAChem Software

Direct Scientific

Eckert & Ziegler Analytics

Ecology Services

EnergySolutions, LLC

F&J Specialty Products
Femto-Tech, Inc.
Fuji Electric Corp of America
G/O Corporation
Gamma Products, Inc.
Health Physics Instruments
HI-Q Environmental Products
Hitachi Aloka Medical, Ltd.
Hopewell Designs, Inc.
IMI-International Medcom, Inc.
J.L. Shepherd & Associates
K&S Associates, Inc.
Lab Impex Systems
Lablogic Systems, Inc.
Landauer
LND, Inc.
Ludlum Measurements, Inc.
Mazur Instruments

Mirion Technologies

ORTEC

Philotechnics, Ltd.

Quest Environmental & Safety Products, Inc.

RADECO

Radiation Detection Co

Radiation Safety & Control Services, Inc.

Radiation Safety Associates

S.E. International, Inc.

SAPHYMO GmbH

Spectrum Techniques, LLC

Technical Associates

Teletrix Corporation

Thermo Fisher Scientific

Tracerco

VF, a.s.

X-Z LAB, Inc.

WWW.VOSS-ASSOCIATES.COM

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