ENVIRONMENT, HEALTH & SAFETY
UNIVERSITY OF MICHIGAN

Phosphorus - 33

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

BETA ENERGY
• 249 keV (maximum)
• 85 keV (average)

Physical Half-Life	25.4 days
Biological Half-Life	1155.0 days
Effective Half-Life	24.9 days

Maximum Beta Range in Air	51.00 cm = 20 inches
Maximum Beta Range in Water/Tissue	0.06 cm = 0.025 inches
Maximum Range in Plexiglas/Lucite/Plastic	0.05 cm = 0.020 inches
Half-Value Layer (HVL)	0.008 cm (water/tissue)

NOTE:

1. A beta with an energy of 795 keV can penetrate to the lens of the eye (0.3 cm) depth.
2. A beta particle with an energy of ≥ 70 keV is required to penetrate the dead layer of skin.
3. Rule of Thumb:
   - 250 keV betas can penetrate about 0.6 mm of tissue/water
   - 250 keV betas can penetrate about 1.7 feet in air

Fraction of P-33 beta particles transmitted through the dead layer of skin (0.007 cm) ~35%

Shielding

Not Required; however, low-density (low atomic number) material is recommended (≥ 3/8" of plexiglas, acrylic, plastic, or plywood).

Volatility

Inherent Volatility (STP): Insignificant

Exposure: Radiological Safety Information

- Tissues with rapid cellular turnover rates show higher retention due to concentration of phosphorus in the nucleoproteins.
- P-33 is eliminated from body primarily via urine.
- Phosphorus Metabolism
  - 30% is rapidly eliminated from body
  - 40% has a 19-day biological half-life
  - 60% of P-33 (ingested) is excreted from body in first 24-hours; only about 1% per day is excreted after the 2nd or 3rd day.

Exposure Prevention

Always wear a lab coat and disposable gloves when handling P-33.

Engineering Controls

- Drying can form airborne P-33 contamination.

Regulatory Compliance Limits (10 CFR 20/Appendix B)

REGULATION	• UNIT OF MEASURE	NOTES
Derived Air Concentration (DAC) (Occupational)	• 4.0E-6 uCi/mL (Class "D") • 1.0E-6 uCi/mL (Class "W")	
Airborne Effluent Release Limit (Annual Average)	• 1.0E-8 uCi/mL (Class "D") • 4.0E-9 uCi/mL (Class "W")	Applicable to the assessment and control of dose to the public (10 CFR 20.1302). If this concentration was inhaled or ingested continuously over one year it would produce a TEDE of 50 millirem.
Urinalysis	Not Required	May be requested by RSS personnel after a radioactive spill of P-33 or a suspected intake
Unrestricted Area Removable Contamination Limit	1,000 dpm/100 cm^2	
Container Labeling Quantity (10 CFR 20.1905)	≥ 100 uCi	

Annual Limit on Intake (ALI)

- 6 millicuries (oral ingestion)
- 8 millicuries (inhalation/Class "D")
- 3 millicuries (inhalation/Class "W")

1.0 ALI = 6 millicurie (ingested) = 5,000 millirem CEDE (Whole Body)

Contamination

Radiological Data

Critical Organ (soluble form)	Bone marrow
Critical Organs (insoluble forms or non-transportable P-33 compounds)	• Lung (inhalation) • G.I. Tract/Lower Large Intestine (ingestion)
Routes of Intake	• Ingestion • Inhalation • Puncture • Wound • Skin Contamination (Absorption)
Internal exposure and contamination are primary radiological concerns.	Committed Dose Equivalent (CDE) = 0.5 millirem/uCi (inhalation)

Skin Contamination (P-33)

- Skin dose, internal contamination, and area contamination are the primary radiological concerns.
- Skin Contamination Dose Rate: 2,659 mrem/hour per 1.0 uCi/cm^2
  - (Dose Rate to Basal Cells) (7 mg/cm^2 or 0.007 cm depth in tissue without air reflection)
- Skin Contamination Dose Rate (Extremity Skin): P-33 betas cannot penetrate 0.3 cm or 30 mg/cm^2 of tissue

Detect Contamination

Survey Instrumentation

- Monitor work areas for removable surface contamination by smearing, swabbing, or wipe testing where P-33 is used. Count smears or swabs in a liquid scintillation counter (LSC).
- Use G-M survey meter and pancake/frisker probe (15.5 cm^2 area). Counting efficiency is approx. 6% for P-33 beta energy (249 keV).
- Liquid scintillation counter (indirect counting) should be used to detect removable P-33 contamination on smears or swabs.

Required Personal Radiation Monitoring

Dosimeters: Not Required (beta particle is too weak)