

Phosphorus - 32

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

BETA ENERGIES

- 1710 keV (maximum)
- 694 keV (average)(100%)

Physical Half-Life	14.3 days
Biological Half-Life	1155 days (Bone)/257 days (Whole Body)
Effective Half-Life	14.1 days (Bone)/13.5 days (Whole Body)
Specific Activity	285,518 curies/gram
Maximum Beta Range in Air	610.00 cm = 240 inches = 20 feet
Maximum Beta Range in Water/Tissue	0.76 cm = 1/3 inch = 0.35 inch
Maximum Range in Plexiglas/Lucite/Plastic	0.61 cm ~ 3/8 inch ~ 0.38 inch

Shielding

Half-Value Layer (HVL)	0.076 cm (water/tissue)
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- DO NOT use lead foil or sheets! Penetrating bremsstrahlung x-rays will be produced!
- Use lead sheets or foil to shield bremsstrahlung x-rays and only AFTER low density plexiglass/acrylic/lucite/wood shielding
- Use low-atomic (low Z) shielding material to shield P-32 and reduce the generation of bremsstrahlung x-rays. The following materials are low Z materials: plexiglass, acrylic, lucite, plastic, wood, or water.
- **Do not** use lead foil, lead sheets, or other high-density (high atomic number) materials to shield P-32 directly. Penetrating bremsstrahlung x-rays will be generated in lead and other high density shielding material.
- Percent of incident P-32 betas converted to bremsstrahlung x-rays: 4.8% (lead), 0.5% (lucite), and 0.3% (wood).

NOTES:

- A beta particle with an energy of 795 keV can penetrate to a depth of the lens of the eye (0.3 cm or 30 mg/cm²).
- A beta particle with an energy of ≥ 70 keV is required to penetrate the dead layer of skin.
- Although the maximum range of a P-32 beta particle is 0.8 cm in tissue/water, approximately 50% are absorbed in the first 0.1 cm of tissue/water.

- Approximately 7% of the P-32 beta particles that expose the surface of the eye can actually penetrate to the depth of the lens of the eye (0.3 cm or 30 mg/cm²).
- Rule of Thumb:
 - 1 MeV betas can penetrate approximately 10 ft in air
 - 1 MeV betas can penetrate approximately 0.4 cm of tissue/H₂O
- Fraction of P-32 beta particles transmitted through the dead layer of skin (7 mg/cm² or 0.007 cm thick) = 95%

Volatility

Inherent Volatility (STP) = Insignificant/Negligible

Exposure: Radiological Safety Information

Exposure Rates

Dose Rate from an unshielded 1.0 millicurie isotropic point source of P-32:

DISTANCE	MRAD/HOUR
1.00 cm	200,000.0
15.24 cm	860.0
10 ft	2.2

Surface dose rate from 1.0 uCi/ml P-32 (in water) is approximately 1480 mrem/h.

Exposure Prevention

- Always wear a lab coat and disposable gloves when handling P-32 Exposure
- Skin (0.007 cm) and lens of the eye (0.3 cm) are primary dose concerns.

Engineering Controls

- Drying can cause airborne P-32 dust contamination.
- Rapid boiling can cause airborne P-32 contamination.
- Expelling P-32 solutions through syringe needles and pipette tips can generate airborne aerosols.

Personal Safety

- P-32 is used as a tracer to study phosphorus-containing processes (nucleotide biochemistry).
- Never work directly over an open container of P-32. Avoid direct eye exposure from penetrating P-32 beta particles.
- Safety glasses or goggles are recommended when working with P-32.

Regulatory Compliance Limits (10 CFR 20/Appendix B)

REGULATION	UNIT OF MEASURE	NOTES
Derived Air Concentration (DAC) (Occupational)	<ul style="list-style-type: none"> 4.0E-7 uCi/mL (all except phosphate) 2.0E-7 uCi/mL (phosphates) 	
Airborne Effluent Release Limit (Annual Average)	<ul style="list-style-type: none"> 1.0E-9 uCi/mL (all except phosphate) 5.0E-10 uCi/mL (phosphates) 	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	However, may be requested by RSS personnel after a radioactive spill of P-32 or a suspected intake.
Unrestricted Area Removable Contamination Limit	1,000 dpm/100 cm ²	
Container Labeling Quantity (10 CFR 20.1905)	≥ 10 uCi	

Annual Limit on Intake (ALI)

- 600 uCi (ingested/all compounds)
- 900 uCi (inhalation/except phosphates)
- 400 uCi (inhalation/phosphates)

* 1.0 ALI = 600 uCi ingested (all compounds) = 5,000 millirem CEDE/WB

Contamination

Radiological Data

Critical Organ (soluble forms)	Bone
Critical Organs (insoluble forms or non-transportable P-32 compounds)	<ul style="list-style-type: none">• Lung (inhalation)• GI Tract/Lower Large Intestine (ingestion)
Routes of Intake	<ul style="list-style-type: none">• Ingestion• Inhalation• Puncture• Wound• Skin Contamination (Absorption)
Internal and External exposure and contamination are concerns with P-32	<p>Committed Dose Equivalent (CDE) (Organ Doses)</p> <ul style="list-style-type: none">• 32 mrem/uCi (ingested)• 37 mrem/uCi (puncture)• 96 mrem/uCi (inhaled/Class W/lungs)• 22 mrem/uCi (inhaled/Class D/bone marrow) <p>Committed Effective Dose Equivalent (CEDE) (Whole Body)</p> <ul style="list-style-type: none">• 8.33 mrem/uCi (ingested/WB)• 5.55 mrem/uCi (inhale/Class D)• 12.50 mrem/uCi (inhale/Class W)

Skin Contamination (P - 32)

Skin contamination (skin dose), lens of the eye dose, ingestion, inhalation, puncture, absorption through skin, and area contamination are primary radiological concerns.

Skin Contamination Dose Rate (Basal) = 5,867 mrem/hour per 1 uCi/cm²

- Localized Dose Rate to Basal Cells at 7 mg/cm² or 0.007 cm tissue depth (without air reflection)
- Very HIGH localized dose received if P-32 contamination remains of skin!

Skin Contamination Dose Rate (Extremity Skin) = 4770 mrem/hour per 1 uCi/cm²

- Bone receives approximately 20% of dose ingested or inhaled for soluble P-32 compounds.
- Tissues with rapid cellular turnover rates show higher retention due to concentration of phosphorus in the nucleoproteins.
- P-32 is eliminated from body primarily via urine.

Phosphorus Metabolism

- 30% is rapidly eliminated from body
- 40% has a 19-day biological half-life
- 30% is reduced by radioactive decay
- 60% of P-32 (ingested) is excreted from body in first 24-hours; only about 1% per day is excreted after the 2nd or 3rd day.

Detect Contamination

Survey Instrumentation

- Monitor for removable surface contamination by smearing, swiping, swabbing, or wipe testing where P-32 is used. Count smears or swabs in a liquid scintillation counter (LSC).
- Monitor your hands, shoes, lab coat, work areas, and floors using a survey meter equipped with a thin-window G-M probe for gross contamination. Preferably, use a sensitive G-M pancake/frisker probe (15.5 cm² monitoring area).
- Use G-M survey meter and, preferably, a pancake/frisker probe (15.5 cm² surface area). Counting efficiency is approximately 25% for P-32.
- Low-energy NaI probe only used to detect bremsstrahlung x-rays
- Liquid scintillation counter (indirect counting) should be used to detect removable surface contamination of P-32 on smears or swabs.
- Typical liquid scintillation counter counting efficiency for P-32 (full window/maximum) ≥ 85%.
- Typical detection limit of P-32 in urine specimens using a liquid scintillation counter = 1.08E-7 uCi/ml.

Required Personal Radiation Monitoring

Dosimeters (Whole Body and Finger Tabs): **Required** when handling ≥ millicuries of P-32 at **any** time.