

Occupational Safety & Environmental Health

Radiation Safety Service

1239 Kipke Drive 1010

[764-4420]

PHOSPHOROUS - 32

[P-32]

PHYSICAL DATA

Beta Energy:	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
Half-Value Layer (HVL):	0.076 cm (water / tissue)

- NOTE:
- (1) 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).
 - (2) A beta particle with an energy of ≥ 70 keV is required to penetrate the dead layer of skin.
 - (3) 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.
 - (4) 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).
 - (5) 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%]

RADIOLOGICAL DATA

- Critical Organ (soluble forms): Bone
- Critical Organs (insoluble forms or non-transportable P-32 compounds): Lung (inhalation) and G.I.Tract / Lower Large Intestine (ingestion)
- Routes of Intake: Ingestion, Inhalation, Puncture, Wound, Skin Contamination (Absorption)
- Internal & external exposure **and** contamination are concerns with P-32.

Committed Dose Equivalent (CDE):	32 mrem/uCi (ingested)
(Organ Doses)	37 mrem/uCi (puncture)
	96 mrem/uCi (inhaled / Class W / lungs)
	22 mrem/uCi (inhaled/Class D/bone marrow)

Committed Effective Dose Equivalent (CEDE): (Whole Body)	8.33 mrem/uCi (ingested / WB) 5.55 mrem/uCi (inhale/Class D) 12.50 mrem/uCi (inhale/Class W)
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]

SKIN CONTAMINATION (P-32):

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 phosphorous in the nucleoproteins.
- P-32 is eliminated from body primarily via urine.
- Phosphorous 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.
- SHIELDING: ≥ 3/8" thick plexiglass / acrylic / lucite / plastic / wood

* [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]

• SURVEY INSTRUMENTATION:

- 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.

PERSONAL RADIATION MONITORING DOSIMETERS (Whole Body and Finger Tabs): **REQUIRED** when handling > 5.0 millicuries of P-32 at **any** time.

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

<u>DISTANCE</u>	<u>mrad/hour</u>
1.00 cm	200,000.0
15.24 cm	860.0
10.00 ft	2.2

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

REGULATORY COMPLIANCE LIMITS (10 CFR 20 / Appendix B)

- Derived Air Concentration (DAC): 4.0E-7 uCi/cc (all except phosphate)
(Occupational) 2.0E-7 uCi/cc (phosphates)
- Airborne Effluent Release Limit:* 1.0E-9 uCi/cc (all except phosphate)
(Annual Average) 5.0E-10 uCi/cc (phosphates)

* Applicable to the assessment & 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 cm²
- Posting Areas or Rooms [10 CFR 20.1902(e)]: >100 uCi
- Container Labeling Requirement [10 CFR 20.1905]: ≥ 10 uCi
- Exempt Quantity [10 CFR 30.18]: 10 uCi
- Limited Quantity [DOT Limits / 49 CFR 173.425]: ≤ 811 uCi
- Type A Quantity [DOT Limits / 49 CFR 173.425]: > 811 uCi

* [Requires Certified Type A Transport Container]

- Reportable Quantity ["RQ" / DOT / 49 CFR 172.101] 100 mCi

* [Indicate "RQ" on transfer/shipping papers & package labels]

GENERAL RADIOLOGICAL SAFETY INFORMATION

- Inherent Volatility (STP): Insignificant / Negligible
- P-32 is used as a tracer to study phosphorous-containing processes (nucleotide biochemistry).
- Skin (0.007 cm) & lens of the eye (0.3 cm) are primary dose concerns.
- Skin contamination (skin dose), lens of the eye dose, ingestion, inhalation, puncture, absorption through skin, and area contamination are primary radiological concerns.
- 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.
- Never work directly over an open container of P-32. Avoid direct eye exposure from penetrating P-32 beta particles.
- **Always** wear a lab coat and disposable gloves when handling P-32.
- 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).
- 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).
- 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).
- Safety glasses or goggles are recommended when working with P-32.
- Typical liquid scintillation counter counting efficiency for P-32 (full window / maximum) \geq 85%.
- Typical detection limit of P-32 in urine specimens using a liquid scintillation counter = 1.08E-7 uCi/ml.