

RADIONUCLIDE INFORMATION

Below are some physical properties and practical handling information for radionuclides most commonly used in the research environment. Contact the RSO for additional information on these materials or other radionuclides.

HYDROGEN-3 (tritium, ^3H , H-3)

Half-life: 12.3 years *Effective Half-life:* 12 days

Decay: β^- (100%) E_{max} : 18.6 keV E_{ave} : 5 keV

Max Range in Air: ~.16 cm (1/16 inch)

Required Area Posting: 10 mCi (370 MBq) *Container Labeling:* 1 mCi (37 MBq)

ALI Ingestion: 80 mCi (3.0 GBq) *ALI Inhalation:* 80 mCi (3.0 GBq)

Critical Organ: whole body

- * ^3H is not an external hazard. The beta particle will not penetrate gloves or the dead layer of skin.
- * ^3H is an internal hazard that may be absorbed through the skin or inhaled. It equilibrates in the body fluids within 3-5 hours. The elimination rate can be increased by increasing fluid intake.
- * Handle large quantities (> 1 mCi) and volatile compounds (e.g. tritiated water) in a fume hood.
- * Lab Monitoring: liquid scintillation counting (40-60% efficiency).
- * Personnel Monitoring: Urinalysis (as directed by RSO).

CARBON-14 (^{14}C , C-14)

Half-life: 5730 years *Effective Half-life:* 12 days

Decay: β^- (100%) E_{max} : 158 keV E_{ave} : 49 keV

Max Range in Air: 22 cm (8.6 inches)

Required Area Posting: 1 mCi (37 MBq) *Container Labeling:* 100 μCi (3.7 MBq)

External dose rate for 1000 dpm/cm²:

9.3 mrem/hr (93 $\mu\text{Sv/hr}$) on contact; 1 mrem/hr (10 $\mu\text{Sv/hr}$) to living skin

ALI Ingestion: 2 mCi (74 MBq) *ALI Inhalation:* 2 mCi (74 MBq)

Critical Organ: whole body

- * ^{14}C is not a significant external hazard. Most beta particles will not penetrate gloves or the dead layer of skin.
- * Most ^{14}C -labeled compounds are rapidly metabolized and exhaled as $^{14}\text{CO}_2$. Some others are eliminated via the urine. Carbonates may concentrate in the bone and halogenated acids may incorporate in the skin.
- * Handle large quantities (> 1 mCi) and volatile compounds in a fume hood.
- * Lab Monitoring:
 - liquid scintillation counting (90% efficiency)
 - open window G-M detector (<10% efficiency)
- * Personnel Monitoring: Urinalysis (as directed by RSO)

SODIUM-22 (^{22}Na , Na-22)

Half-life: 2.62 years *Effective Half-life:* 11 days

Decay: β^+ (90.6%) E_{max} : 545 keV E_{ave} : 215 keV

Electron Capture (9.4%)

γ : 1.275 MeV (100%), 0.511 MeV (180%)

Required Area Posting: 100 μCi (3.7 MBq) *Container Labeling:* 10 μCi (0.37 MBq)

Exposure rate from 1 mCi (37 MBq) at 1 cm: 11.8 R/hr

ALI ingestion: 400 μCi (15 MBq) *ALI inhalation:* 600 μCi (22 MBq)

Critical Organ: Whole body

- * Shield with lead bricks.
- * Lab Monitoring: G-M or NaI survey meter; gamma well counter
- * Personnel Monitoring: Whole body and finger ring dosimeter (as needed)

PHOSPHORUS-32 (^{32}P , P-32)

Half-life: 14.3 days *Effective Half-life:* 14.3 days

Decay: β^- (100%) E_{max} : 1.71 MeV E_{ave} : 0.694 MeV

Max Range in Air: 5.5 m (18 feet)

Required Area Posting: 100 μCi (3.7 MBq) *Container Labeling:* 10 μCi (0.37 MBq)

Dose rate for 1000 dpm/cm²:

1.8 mrem/hr (18.3 $\mu\text{Sv/hr}$) on contact

1.7 mrem/hr (16.7 $\mu\text{Sv/hr}$) to the living skin

ALI ingestion: 600 μCi (22 MBq) *ALI inhalation:* 900 μCi (33 MBq)

Critical Organ: bone (internal), skin, eyes (external)

- * ^{32}P -labeled compounds are readily absorbed through the skin. About 60% of ^{32}P ingested will be excreted within 24 hours through the urine and about 1%/day thereafter.
- * Shield with 0.5 inch or more of plastic or wood. Lead or steel shielding produces bremsstrahlung x-rays, which are more difficult to stop.
- * Use remote handling devices (e.g. forceps, trays) to minimize direct handling.
- * Eye protection is recommended to reduce exposure to eyes.
- * Use vinegar to clean contaminated skin.
- * Extremity dosimetry is recommended when handling quantities of 5 mCi or more.
- * Lab Monitoring:
 - liquid scintillation counting
 - scintillation fluid (90% efficiency); Cherenkov counting (<50% efficiency)
 - open window G-M detector (good detectability)
 - NaI detector for bremsstrahlung x-rays
- * Personnel Monitoring:
 - whole body and/or finger ring dosimeter, particularly when handling large quantities
- * ^{32}P waste must also be shielded.

Precautions When Pipetting Millicurie Quantities of ^{32}P

- * With 1 mCi of ^{32}P in ml in an open vial, the dose rate at 15 cm (6 inches) is about 2 rem/hour. The dose rate is predominantly from beta radiation. The bremsstrahlung x-ray contribution is very small.
- * A liquid-filled pipette tip or the petri dish after pipetting can be a source of exposure to hands. A significant depth of liquid in a petri dish can partially shield the beta radiation.
- * Pipetting should take place behind a 3/8-inch plastic shield to protect the torso and head. Optimize positioning of the stock vial and the final container to minimize travel time and distance. Use a tray, such as a cafeteria tray, to transport petri dishes or other similar containers. A plastic shield over the dishes will further reduce personal exposure.
- * Remove the pipetting hand out of the beam from the stock vial as soon as possible after removing the pipette tip from the stock vial. Remove and replace the stock vial cap using tongs. Get the cap back on immediately after pipetting.
- * For multi-millicurie quantities of ^{32}P , a plastic shield on the pipette is appropriate to substantially reduce the dose to the pipetting hand.
- * Once pipetting is done, the used tip should go directly into a shielded waste container.
- * Monitor gloves frequently during use and immediately afterward. If contamination is found, remove them and adjust your technique to eliminate the cause. Do not accept routine contamination on gloves. The dose rate from ^{32}P directly on the skin is about 8800 mrem/hour per $\mu\text{Ci}/\text{cm}^2$. A layer or two of gloves will not decrease that dose rate by much.

PHOSPHORUS-33 (^{33}P , P-33)

Half-life: 24.4 days

Decay: β^- (100%) E_{max} : 248 keV E_{ave} : 77 keV

Max Range in Air: 45 cm (18 inches)

Required Area Posting: 1 mCi (37 MBq) *Container Labeling:* 100 μCi (3.7 MBq)

ALI ingestion: 6 mCi (220 MBq) *ALI inhalation:* 8 mCi (300 MBq)

Critical Organ: bone

- * ^{33}P is not a significant external hazard. Most beta particles will not penetrate gloves or the dead layer of skin.
- * Handle large quantities (> 1 mCi) and volatile compounds in a fume hood.
- * Lab Monitoring:
 - liquid scintillation counting (90% efficiency)
 - open window G-M detector
- * Personnel Monitoring: Urinalysis (as directed by RSO)

SULFUR-35 (^{35}S , S-35)

Half-life: 87.4 days *Effective Half-life:* 44-90 days

Decay: β^- (100%) E_{max} : 167 keV E_{ave} : 48 keV

Max Range in Air: 24 cm (9.6 inches)

Required Area Posting: 1 mCi (37 MBq) *Container Labeling:* 100 μCi (3.7 MBq)

Dose rate for 1000 dpm/cm²:

93 μ Sv/hr (9.3 mrem/hr) on contact

10 μ Sv/hr (1 mrem/hr) to skin

ALI ingestion: 6 mCi (220 MBq) *ALI inhalation:* 2 mCi (74 MBq)

Critical Organ: Testes; whole body

- * ³⁵S is not a significant external hazard. Most beta particles will not penetrate gloves or the dead layer of skin.
- * Most ³⁵S-labeled compounds are eliminated by the urine.
- * Handle large quantities (> 1 mCi) and volatile compounds in a fume hood.
- * Lab Monitoring:
 - liquid scintillation counting (90% efficiency)
 - open window G-M detector (<10% efficiency)
- * Personnel Monitoring: Urinalysis (as directed by RSO)

CHLORINE-36 (³⁶Cl, Cl-36)

Half-life: 3.08 x 10⁵ years *Effective Half-life:* 10 days (NaCl); 29 days (other cmpds)

Decay: β^- E_{max}: 714 keV (98%) E_{ave}: 251 keV; electron capture (1.9%)

γ 511 keV (0.003%)

Required Area Posting: 100 μ Ci (3.7 MBq) *Container Labeling:* 10 μ Ci (0.37 MBq)

ALI (chlorides of Na, K, H): [see CFR20, App B for other chloride forms]

Ingestion: 2 mCi (74 MBq) *Inhalation:* 2 mCi (74 MBq)

Critical Organ: Whole body (soluble compounds); lung (inhalation)

- * Shield ³⁶Cl with 6 mm (¼ inch) plastic and lead.
- * Lab Monitoring:
 - liquid scintillation counting (100% efficiency)
 - open window G-M detector
- * Personnel Monitoring: Whole body dosimeter; urinalysis (if directed by RSO)

CALCIUM-45 (⁴⁵Ca, Ca-45)

Half-life: 165 days *Effective Half-life:* 162 days

Decay: β^- E_{max}: 254 keV (100%) E_{ave}: 76 keV

Max Range in Air: ~45 cm (19 inches)

Required Area Posting: 1 mCi (37 MBq) *Container Labeling:* 100 μ Ci (3.7 MBq)

ALI Ingestion: 2 mCi (74 MBq) *ALI Inhalation:* 800 μ Ci (30 MBq)

Critical Organ: bone

- * ⁴⁵Ca is not a significant external hazard. The low energy beta particles will barely penetrate the gloves and outer layer of skin.
- * Lab Monitoring:
 - liquid scintillation counting (90% efficiency)
 - open window G-M detector
- * Personnel Monitoring: Urinalysis (as directed by RSO)

NICKEL-63 (^{63}Ni , Ni-63)*Half-life:* 96 years*Decay:* β^- (100%) E_{max} : 66 keV E_{ave} : 17 keV*Required Area Posting:* 1 mCi (37 MBq) *Container Labeling:* 100 μCi (3.7 MBq)*ALI ingestion:* 9 mCi (3.3 MBq) *ALI inhalation (vapor):* 800 μCi (3 MBq)

- * ^{63}Ni is not an external hazard because the low-energy beta particles do not penetrate the outer layer of skin.
- * Used as sealed source for electron capture detectors in gas chromatography equipment (see section 2.23.2).
- * Lab Monitoring: liquid scintillation counting
- * Personnel Monitoring: urinalysis (as directed by RSO)

ZINC-65 (^{65}Zn , Zn-65)*Half-life:* 244 days*Effective Half-life:* 194 days*Decay:* β^+ : 330 keV (1.4%); γ : 1115 keV (50.7%)*Required Area Posting:* 100 μCi (3.7 MBq) *Container Labeling:* 10 μCi (0.37 MBq)*Exposure rate from 1 mCi (37 MBq) at 1 m ~ 0.3 mR/hr**ALI ingestion:* 400 μCi (14.8 MBq) *ALI inhalation:* 300 μCi (11.1 MBq)

- * Use lead shielding.
- * Lab Monitoring: G-M detector, NaI detector, gamma well counter, liquid scintillation
- * Personnel Monitoring: Whole body dosimeter, extremity dosimeter (per RSO)

INDIUM-111 (^{111}In , In-111)*Half-life:* 2.8 days*Decay:* electron capture; β^- : 144 keV (7.9%), 218 keV (5%) γ : 245 keV (94%), 171 keV (90%)*Required Area Posting:* 1 mCi (37 MBq) *Container Labeling:* 100 μCi (3.7 MBq)*Exposure rate from 1 mCi (37 MBq) at 1 cm: 1.8 Rad/hr (18 mGy/hr)**ALI ingestion:* 4 mCi (148 MBq) *ALI inhalation:* 6 mCi (222 MBq)

- * Use lead shielding.
- * Lab Monitoring:
 - G-M detector, NaI detector
 - gamma well counter
- * Personnel Monitoring (^{111}In): Whole body dosimeter, extremity dosimeter for mCi quantities

IODINE-125 (^{125}I , I-125)*Half-life:* 59.6 days *Effective Half-life:* 42 days*Decay:* γ : 35.5 keV (6.7%); x-ray 27.3 keV (114%)*Required Area Posting:* 10 μCi (370 kBq) *Container Labeling:* 1 μCi (37 kBq)*Exposure rate from 1 mCi (37 MBq) at 1 cm: 0.7 R/hr**ALI ingestion:* 40 μCi (1.48 MBq) *ALI inhalation:* 60 μCi (2.22 MBq)

Critical Organ: thyroid

- * About 30% of free iodine taken into the body will concentrate in the thyroid delivering a dose of 1.13 mSv/Bq (4.2 rem/ μ Ci). Use great care to avoid intake.
- * See section 2.22.2 regarding iodination (Na^{125}I) procedures.
- * No shielding is necessary when using amounts less than 50 μ Ci (1.85 MBq). Use 1/32 inch (0.78 mm) lead shielding for quantities up to 1 mCi.
- * Open and handle quantities greater than 10 μ Ci in a fume hood. Millicurie quantities are handled in a iodination hood insert with activated charcoal traps.
- * Lab Monitoring:
 - NaI (Low-energy gamma) detector (<20% efficiency)
 - liquid scintillation counting (40-50% efficiency)
 - gamma well counter (90% efficiency)
- * Personnel Monitoring: thyroid bioassays (as directed by the RSO).

CESIUM-137 (^{137}Cs , Cs-137)

Half-life: 30 years *Effective Half-life:* 70 days

Decay: β^- E_{max} : 1173 keV (5.5%); 511 keV (94.4%)

γ 662 keV (85.1%)

Required Area Posting: 100 μ Ci (3.7 MBq) *Container Labeling:* 10 μ Ci (0.37 MBq)

Exposure rate from 1 mCi (37 MBq) at 1 cm: 2.6 rem/hr (26 mSv/hr)

ALI Ingestion: 100 μ Ci (3.7 MBq) *ALI Inhalation:* 200 μ Ci (7.4 MBq)

Critical Organ: whole body

- * License only allows sealed sources.
- * Shield with lead.
- * Lab Monitoring: survey meter with G-M or NaI probe
- * Personnel Monitoring: Whole body dosimeter

MERCURY-203 (^{203}Hg , Hg-203)

Half-life: 46.6 days *Effective Half-life:* 11 days

Decay: β^- (100%) E_{max} : 213 keV E_{ave} : 57.9 keV; γ : 279 keV (81.5%)

Required Area Posting: 1 mCi (37 MBq) *Container Labeling:* 100 μ Ci (3.7 MBq)

Exposure rate for 1 mCi at 1 meter \approx 0.013 mR/hr.

ALI Ingestion: 500 μ Ci *ALI Inhalation:* 800 μ Ci

Critical Organ: Kidney

- * Shield with lead.
- * Lab Monitoring: G-M or NaI survey meter; gamma well counter; liquid scintillation
- * Personnel Monitoring: Whole body and finger ring dosimeter (as needed)