^{3}H	Nuclide Safety Data Sheet Hydrogen-3 [Tritium]	^{3}H

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 18.6 keV; Average: 5.7 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	12.3 years
	Biological $T_{½}$:	10 - 12 days
	Effective $T_{½}$:	10 - 12 days*

* Large liquid intake (3-4 liters/day) reduces effective $T_{½}$ by a factor of 2+; ^{3}H is easily flushed from the body

Specific Activity:	9650 Ci/g [357 TBq/g] max.	
Beta Range:	Air:	6 mm [0.6 cm; 0.25 inches]
	Water:	0.006 mm [0.0006 cm; 3/10,000 inches]
	Solids/Tissue:	Insignificant [No ^{3}H betas pass through the dead layer of skin]

II. RADIOLOGICAL DATA

Radiotoxicity:	Least radiotoxic of all nuclides; CEDE, ingestion or inhalation: Tritiated water: 1.73E-11 Sv/Bq (0.064 mrem/uCi) of ^{3}H intake Organic Compounds: 4.2E-11 Sv/Bq (0.16 mrem/uCi) of ^{3}H intake
Critical Organ:	Body water or tissue
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure - None from weak ^{3}H beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the only readily available method to assess intake [for tritium, no intake = no dose] Be sure to provide a urine sample to Radiation Safety for confirmatory bioassay whenever your annual ^{3}H use exceeds 8 mCi. If negative, no further bioassay is required unless use exceeds 100 mCi at one time or 1000 mCi in one year, or after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Liquid Scintillation Counting is the only readily available method for detecting ^{3}H
NOTE: PORTABLE SURVEY METERS WILL NOT DETECT LABORATORY QUANTITIES OF ^{3}H

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many tritium compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.
- While tritiated DNA precursors are considered more toxic that $^{3}H_2O$, they are generally less volatile and hence do not normally present a greater hazard
- The inability of direct-reading instruments to detect tritium and the slight permeability of most material to [tritiated] water & hydrogen [tritium] facilitates undetected spread of contamination. Use extreme care in handling and storage [e.g. sealed double or multiple containment] to avoid contamination, especially with high specific activity compounds.

^{14}C	Nuclide Safety Data Sheet Carbon-14	^{14}C

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Max.: 156 keV; Average: 49 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	5730 years
	Biological $T_{½}$:	12 days
	Effective $T_{½}$:	Bound - 12 days; unbound - 40 days
Specific Activity:	4.46 Ci/g [0.165 TBq/g] max.	
Beta Range:	Air:	24 cm [10 inches]
	Water/Tissue:	0.28 mm [0.012 inches]
	[~1% of ^{14}C betas transmitted through dead skin layer, i.e. 0.007 cm depth]	
	Plastic:	0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity:	0.023 mrem/uCi of $^{14}CO_2$ inhaled; 2.09 mrem/uCi organic compounds inhaled/ingested
Critical Organ:	Fat tissue [most labeled compounds]; bone [some labeled carbonates]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure – None from weak ^{14}C beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{14}C, no intake = no dose]
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [~10% efficiency];
Beta Scintillator [~5% efficiency]

Wipe Test: Liquid Scintillation Counting is the best readily available method for counting ^{14}C wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Many ^{14}C compounds readily penetrate gloves and skin; handle such compounds remotely and wear double gloves, changing the outer pair at least every 20 minutes.

^{32}P	Nuclide Safety Data Sheet Phosphorous-32	^{32}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 1,710 keV; Average: 695 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	14.29 days
	Biological $T_{½}$:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective $T_{½}$:	14.29 days
Specific Activity:	286,500 Ci/g [10,600 TBq/g] max.	
Beta Range:	Air:	610 cm [240 inches; 20 feet]
	Water/Tissue:	0.76 cm [0.33 inches]
	Plastic:	0.61 mm [3/8 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	94.7 mrem/uCi [Lung] & 15.5 mrem/uCi [CEDE] of ^{32}P inhaled 29.9 mrem/uCi [Bone Marrow] & 8.77 mrem/uCi [CEDE] of ^{32}P ingested
Critical Organ:	Bone [soluble ^{32}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure [unshielded dose rate at 1 mCi ^{32}P vial mouth[3]: approx. 26 rem/hr], Internal Exposure & Contamination

III. SHIELDING

Shield ^{32}P with 3/8 inch Plexiglas and monitor for Bremstrahlung; If Bremstrahlung X-rays detected outside Plexiglas, apply 1/8 to 1/4 inch lead [Pb] shielding outside Plexiglas
The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Wear radiation dosimetry monitoring badges [body & ring] if regularly handling mCi quantities of ^{32}P

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller
Wipe Test: Liquid Scintillation Counting is an acceptable method for counting ^{32}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake].
- Store ^{32}P (including waste) behind Plexiglas shielding [3/8 inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background); apply lead [Pb] shielding outside Plexiglas if needed.
- Use 3/8 inch Plexiglas shielding to minimize exposure while handling ^{32}P.
- Use tools [e.g. Beta Blocks] to handle ^{32}P sources and contaminated objects; avoid direct hand contact.
  - Always have a portable survey meter present and turned on when handling ^{32}P.
- ^{32}P is not volatile, even when heated, and can be ignored as an airborne contaminant[4] unless aerosolized.

---

[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Dupont/NEN, Phosphorous-32 Handling Precautions [Boston, MA; NEN Products, 1985]
[4] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

^{35}S	Nuclide Safety Data Sheet Sulfur-35	^{35}S

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 167.47 keV; Average: 48.8 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	87.44 days
	Biological $T_{½}$:	623 days [unbound ^{35}S]; 90 days [bound ^{35}S]
	Effective $T_{½}$:	44 - 76 days [unbound ^{35}S]
Specific Activity:	42,707 Ci/g [1,580 TBq/g] max.	
Beta Range:	Air:	26 cm [10.2 inches]
	Water/Tissue:	0.32 mm [0.015 inches]
	Plastic:	0.25 mm [0.010 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[1]:	2.48 mrem/uCi [CEDE] of ^{35}S inhaled 0.733 mrem/uCi of ^{35}S ingested
Critical Organ:	Testis
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External Exposure – None from weak ^{35}S beta Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake [for ^{35}S, no intake = no dose]
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [~10% efficiency]
Beta Scintillator [~5% efficiency]

Wipe Test: Liquid Scintillation Counting is the best readily available method for counting ^{35}S wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
  - Many ^{35}S compounds and metabolites are slightly volatile and may create contamination problems if not sealed or otherwise controlled. This occurs particularly when ^{35}S amino acids are thawed, and when they are added to cell culture media and incubated. Therefore vent thawing ^{35}S vials in a hood. Incubators used with ^{35}S will have an activated charcoal trap placed in the incubator. Possibility of volatilization must be taken into account when surveying after use.

[1] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122,156

^{45}Ca	Nuclide Safety Data Sheet Calcium-45	^{45}Ca

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 257 keV; Average: 77 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	162.61 days
	Biological $T_{½}$:	Bone ~ 18,000 days[1]
	Effective $T_{½}$:	163 Days
Specific Activity:	17,800 Ci/g [659 TBq/g] max.	
Beta Range:	Air:	52 cm [20 inches]
	Water/Tissue:	0.062 cm [0.024 inches]
	Plastic	0.053 cm [0.021 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]: 35.8 mrem/uCi [Lung] & 16.2 mrem/uCi [Bone] of ^{45}Ca inhaled
19.4 mrem/uCi [Bone] & 3.2 mrem/uCi [CEDE] of ^{45}Ca ingested

Critical Organ: Bone; Lung [Inhalation]

Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption

Radiological Hazard: External Exposure - mCi quantities not considered an external hazard
Internal Exposure & Contamination - Primary concern

III. SHIELDING

None required - mCi quantities not an external radiation hazard

IV. DOSIMETRY MONITORING

Urine bioassay is the most readily available method to assess intake. Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected.
No dosimetry badges needed to work with mCi quantities of ^{45}Ca.

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller
Wipe Test: Liquid Scintillation Counting works well for counting ^{45}Ca wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]

[1] "Calcium-45 Handling Precautions", E.I. DuPont de Numours & Co., NEN Products [Boston, MA; 1985]
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156

^{125}I	Nuclide Safety Data Sheet Iodine-125	^{125}I

I. PHYSICAL DATA

Radiation:	Gamma - 35.5 keV (7% abundance)
	X-ray - 27 keV (113% abundance)
Gamma Constant:	0.27 mR/hr per mCi @ 1.0 meter [7.432E-5 mSv/hr per MBq @ 1.0 meter][1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 60.14 days
	Biological $T_{½}$: 120-138 days (unbound iodine)
	Effective $T_{½}$: 42 days (unbound iodine)
Specific Activity:	1.73E4 Ci/g [642 TBq/g] max.

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	3.44E-7 Sv/Bq (1273 mrem/uCi) of ^{125}I ingested [Thyroid]
	2.16 E-7 Sv/Bq (799 mrem/uCi) of ^{125}I inhaled [Thyroid]
Critical Organ:	Thyroid Gland
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	0.02 mm (0.0008 inches)	0.07 mm (0.003 inches)

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling > 10 µCi of ^{125}I
- Conduct a baseline thyroid scan prior to first use of 1 mCi or more of radioactive iodine
- Conduct thyroid scan no earlier than 6 hours but within 72 hours of handling 1 mCi or more of ^{125}I or after any suspected intake

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller

Low Energy Gamma Detector [~19% eff. for ^{125}I] for contamination surveys

Wipe Test: Liquid Scintillation Counter or Gamma Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{125}I
- Avoid making low pH [acidic] solutions containing ^{125}I to avoid volatilization
- For Iodinations:
  - Use a cannula adapter needle to vent stock vials of ^{125}I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other tight caps to prevent release while counting or moving outside the fume hood.

[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998] p. 6-11

[2] Federal Guidance Report No. 11 (Oak Ridge TN; Oak Ridge National Laboratory, 1988) P. 136, 166