## Nuclide Safety Data Sheet
### Hydrogen-3 [Tritium]

### I. PHYSICAL DATA

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Beta (100% abundance)</td>
</tr>
<tr>
<td>Energy</td>
<td>Max.: 18.6 keV; Average: 5.7 keV</td>
</tr>
<tr>
<td>Half-Life ([T_{1/2}])</td>
<td>Physical (T_{1/2}): 12.3 years</td>
</tr>
<tr>
<td></td>
<td>Biological (T_{1/2}): 10 - 12 days</td>
</tr>
<tr>
<td></td>
<td>Effective (T_{1/2}): 10 - 12 days*</td>
</tr>
</tbody>
</table>

* Large liquid intake (3-4 liters/day) reduces effective \(T_{1/2}\) by a factor of 2+; \(^3\text{H}\) is easily flushed from the body

| Specific Activity         | 9650 Ci/g \([357 \text{ TBq/g}]\) max. |
| Beta Range                | Air: 6 mm \([0.6 \text{ cm}; 0.25 \text{ inches}]\) |
|                          | Water: 0.006 mm \([0.0006 \text{ cm}; 3/10,000 \text{ inches}]\) |
|                          | Solids/Tissue: Insignificant [No \(^3\text{H}\) 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 \((0.064 \text{ mrem/uCi})\) of \(^3\text{H}\) intake |
|                          | Organic Compounds: 4.2E-11 Sv/Bq \((0.16 \text{ mrem/uCi})\) of \(^3\text{H}\) intake |
| Critical Organ            | Body water or tissue |
| Exposure Routes           | Ingestion, inhalation, puncture, wound, skin contamination absorption |
| Radiological Hazard       | External Exposure - None from weak \(^3\text{H}\) 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 \(^3\text{H}\) 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 \(^3\text{H}\).

**NOTE:** PORTABLE SURVEY METERS WILL NOT DETECT LABORATORY QUANTITIES OF \(^3\text{H}\)

### 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 than \(^3\text{H}_2\text{O}\), 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.
I. PHYSICAL DATA

Radiation: Beta (100% abundance)
Energy: Max.: 156 keV; Average: 49 keV
Half-Life \[T_{1/2}\] :
   Physical \[T_{1/2}\]: 5730 years
   Biological \[T_{1/2}\]: 12 days
   Effective \[T_{1/2}\]: 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 \(^{14}\text{C}\) 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/μCi of \(^{14}\text{CO}_2\) inhaled;
               2.09 mrem/μCi 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 \(^{14}\text{C}\) 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}\text{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 \(^{14}\text{C}\) wipe tests

VI. SPECIAL PRECAUTIONS

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

Radiation: Beta (100% abundance)
Energy: Maximum: 1,710 keV; Average: 695 keV
Half-Life \([T_{1/2}]\):
  - Physical \(T_{1/2}\): 14.29 days
  - Biological \(T_{1/2}\): Bone ~ 1155 days; Whole Body ~ 257 days
  - Effective \(T_{1/2}\): 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:
  - 94.7 mrem/μCi [Lung] & 15.5 mrem/μCi [CEDE] of \(^{32}\)P inhaled
  - 29.9 mrem/μCi [Bone Marrow] & 8.77 mrem/μCi [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]: 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 unless aerosolized.

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1 NCRP Report No. 65, p.88
3 Dupont/NEN, Phosphorous-32 Handling Precautions [Boston, MA: NEN Products, 1985]
# Nuclide Safety Data Sheet

## Sulfur-35

### I. PHYSICAL DATA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation</td>
<td>Beta (100% abundance)</td>
</tr>
<tr>
<td>Energy</td>
<td>Maximum: 167.47 keV; Average: 48.8 keV</td>
</tr>
<tr>
<td>Half-Life ( T_{1/2} ):</td>
<td>Physical ( T_{1/2} ): 87.44 days</td>
</tr>
<tr>
<td></td>
<td>Biological ( T_{1/2} ): 623 days [unbound (^{35}\text{S})]; 90 days [bound (^{35}\text{S})]</td>
</tr>
<tr>
<td></td>
<td>Effective ( T_{1/2} ): 44 - 76 days [unbound (^{35}\text{S})]</td>
</tr>
<tr>
<td>Specific Activity</td>
<td>42,707 Ci/g [1,580 TBq/g] max.</td>
</tr>
<tr>
<td>Beta Range</td>
<td>Air: 26 cm [10.2 inches]</td>
</tr>
<tr>
<td></td>
<td>Water/Tissue: 0.32 mm [0.015 inches]</td>
</tr>
<tr>
<td></td>
<td>Plastic: 0.25 mm [0.010 inches]</td>
</tr>
</tbody>
</table>

### II. RADIOLOGICAL DATA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiotoxicity¹</td>
<td>2.48 mrem/uCi [CEDE] of (^{35}\text{S}) inhaled</td>
</tr>
<tr>
<td></td>
<td>0.733 mrem/uCi of (^{35}\text{S}) ingested</td>
</tr>
<tr>
<td>Critical Organ</td>
<td>Testis</td>
</tr>
<tr>
<td>Exposure Routes</td>
<td>Ingestion, inhalation, puncture, wound, skin contamination absorption</td>
</tr>
<tr>
<td>Radiological Hazard</td>
<td>External Exposure – None from weak (^{35}\text{S}) beta</td>
</tr>
<tr>
<td></td>
<td>Internal Exposure &amp; Contamination - Primary concern</td>
</tr>
</tbody>
</table>

### 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 \(^{35}\text{S}\), no intake = no dose]
Provide a urine sample to Radiation Safety after any accident/incident in which an intake is suspected

### V. DETECTION & MEASUREMENT

<table>
<thead>
<tr>
<th>Portable Survey Meters</th>
<th>Beta Scintillator [~5% efficiency]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geiger-Mueller [-10% efficiency]</td>
</tr>
</tbody>
</table>

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

### VI. SPECIAL PRECAUTIONS

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

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¹ Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122,156
# Calcium-45 (\(^{45}\text{Ca}\))

## I. PHYSICAL DATA
- **Radiation:** Beta (100% abundance)
- **Energy:**
  - Maximum: 257 keV
  - Average: 77 keV
- **Half-Life \([T_{1/2}]\):**
  - Physical \(T_{1/2}\): 162.61 days
  - Biological \(T_{1/2}\): Bone \(\sim\) 18,000 days
  - Effective \(T_{1/2}\): 163 Days
- **Specific Activity:** 17,800 Ci/g \([659 \text{ TBq/g}]\) max.
- **Beta Range:**
  - Air: 52 cm \([20 \text{ inches}]\)
  - Water/Tissue: 0.062 cm \([0.024 \text{ inches}]\)
  - Plastic (Lucite): 0.053 cm \([0.021 \text{ inches}]\)

## II. RADIOLOGICAL DATA
- **Radiotoxicity:**
  - 35.8 mrem/uCi [Lung] & 16.2 mrem/uCi [Bone] of \(^{45}\text{Ca}\) inhaled
  - 19.4 mrem/uCi [Bone] & 3.2 mrem/uCi [CEDE] of \(^{45}\text{Ca}\) 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 \(^{45}\text{Ca}\).

## V. DETECTION & MEASUREMENT
- **Portable Survey Meters:** Geiger-Mueller
- **Wipe Test:** Liquid Scintillation Counting works well for counting \(^{45}\text{Ca}\) wipe tests

## VI. SPECIAL PRECAUTIONS
- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]

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# Nuclide Safety Data Sheet
## Iodine-125

### 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 [7.43E-5 mSv/hr per MBq @ 1.0 meter]

Half-Life \(T_{1/2}\):  
- Physical \(T_{1/2}\): 60.14 days
- Biological \(T_{1/2}\): 120-138 days (unbound iodine)
- Effective \(T_{1/2}\): 42 days (unbound iodine)

Specific Activity: 1.73E4 Ci/g [642 TBq/g] max.

### II. RADIOLOGICAL DATA

Radiotoxicity\(^1\):  
- 3.44E-7 Sv/Bq (1273 mrem/uCi) of \(^{125}\)I ingested [Thyroid]
- 2.16E-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

<table>
<thead>
<tr>
<th>Material</th>
<th>Half Value Layer [HVL]</th>
<th>Tenth Value Layer [TVL]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead [Pb]</td>
<td>0.02 mm (0.0008 inches)</td>
<td>0.07 mm (0.003 inches)</td>
</tr>
</tbody>
</table>

- 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.

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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