Yale University

Office of Environmental Health & Safety
135 College Street, 1st Floor
New Haven, Connecticut 06510-2411

Telephone: 203-785-3550
Fax: 203-785-7588
www.yale.edu/oehs

Safety Information and Specific Handling Precautions for Radionuclides H-3, C-14, S-35, P-32 and I-125

Tritium (3 H) safety information and specific handling precautions

General:

Tritium is a very low energy beta emitter and even large amounts of this isotope pose no external dose hazard to persons exposed. The beta radiation cannot penetrate the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor. The critical organ for a tritium uptake is the water of the whole body. Three to four hours after an intake of tritiated water, the radioactive material is uniformly distributed throughout the body fluids. A tritium intake may be easily detected by analyzing a urine sample.

Many tritium compounds readily migrate through gloves and skin. Data from accidents involving tritium indicate that 80% of the body exposure occurs through skin absorption. Tritium compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. Tritiated DNA precursors are considered more toxic than tritiated water. However, they are generally less volatile and do not normally present a significantly greater hazard.

Physical Data:

Maximum beta energy: 0.019 MeV, 100% emission.
Maximum range in air: About 1/6 of an inch
Radiological Half-life: 12.28 years.
Internal Occupational Limits:
Annual Limits on Intake-
Inhalation: 80 mCi
Ingestion: 80 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes.

2. Traps may be necessary to collect tritium if large gas or vapor releases are anticipated. This will reduce the release to the environment.

3. Monitor surfaces routinely and keep record of the results. Geiger counters (survey meters) are not sensitive to tritium radiation and therefore wipe tests and a liquid scintillation counter are necessary to determine levels of contamination. Radiation badges are not issued to individuals using only tritium because the radiation emitted by tritium is not of sufficient strength to penetrate the badge.

4. Submit urine samples for analysis if requested to do so by the Radiation Safety Section. Yale's current Nuclear Regulatory Commission license requires an individual to submit a urine sample when working with 100 mCi or more of tritium at one time.

5. High activity tritium experiments may be performed in one of two laboratories (KBT 1138 and BCMM B-01) maintained by the Radiation Safety Section. Storage space is also available for high activity tritium stock solutions.

6. Due to the long half-life of tritium, tritiated waste must be segregated from short-lived waste. 3 H and 14 C waste may be combined, but must be kept separate from 32 P,35 S,125 I and other radioactive waste.

7. Tritium can penetrate plastic and other materials. Stock vials should therefore be wipe tested routinely (ie, quarterly) to help prevent/control the escape of tritium from storage containers.

^3H LAB INFO SHEET

^3H Tritium

Very Low Energy Beta Emitter
Half-Life: 12.28 Years
Max energy: 19 KeV (at 100%)
Max range in air: 1/6th inch
ALI = 80mCi (Ingestion/Inhalation)
Critical Organ: Whole Body
Bioassay: Urine

Detection: Wipe test
Instrument: LSC ONLY (60-70%) efficient

Shielding: None Required

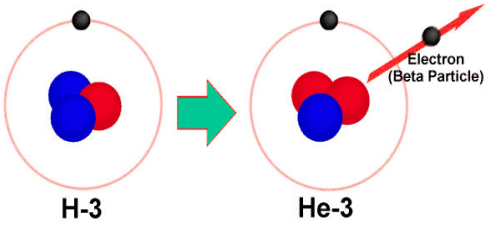
PPE: Double gloves, Lab coat, Safety glasses

Dosimetry: None Needed

LSC

Notes and Special Precautions

- ^3H can NOT be detected with a portable survey meter. Surveys must be conducted using wipes and Liquid Scintillation Counting (LSC).
- Wipe tests required after each use.
- Liquid Scintillation Counter (LSC) efficiencies for ^3H= 60 -70%.
- ^3H spills are difficult to contain and time consuming to clean up. EHS Radiation Safety should be called immediately in the event of ANY ^3H incident.
- ^3H migrates - through containers (over time) and gloves.^3H can contaminate inside of freezer, thus double containment is advised. Labs are encouraged to dispose of ^3H when done using material. Even though ^3H has a long half life, chemically it degrades and may not be useful.
- Urine bioassays required for some users; specifically required for those using > 100 mCi at a time, but also performed sometimes when 10 mCi is handled, tritiated water is used, or as follow up to ^3H spills.



Class IV Waste ≥ 120 days Can be combined with ^{14}C

EMERGENCY SPILLS or SKIN CONTAMINATION

785-3555

Or 911 after hours

Yale *Environmental Health & Safety* *785-3550*

NO EATING, DRINKING, OR SMOKING in lab.

Carbon-14 (14 C) safety information and specific handling precautions

General:

Carbon-14 is a low energy beta emitter and even large amounts of this isotope pose little external dose hazard to persons exposed. The beta radiation barely penetrates the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor (usually radioactive CO2). The critical organ for most 14 C labelled compounds is the fat of the whole body. The most hazardous chemical form of 14 C is labelled carbonates for which the bone is a critical organ. Ingested carbon is metabolized very quickly and much of the radionuclide is exhaled in the form of radioactive carbon dioxide. Urine analysis is an effective sampling technique to determine if a 14 C uptake has occurred.

Some 14 C labelled compounds may migrate through gloves and skin. 14 C compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. One should be careful not to contaminate the skin as some 14 C beta particles penetrate the dead layer of the epidermis. Special caution should be taken when handling 14 C labeled halogenated acids. These compounds may be incorporated in the skin, causing very large skin doses and a pathway into the body.

Physical Data:

Maximum beta energy: 0.156 MeV, 100% emission
Maximum range in air: about 8.6 inches
Radiological Half-life: 5730 years
Internal Occupational Limits:
Annual Limits on Intake-
Inhalation: 2 mCi
Ingestion: 2 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes.

2. Traps may be necessary to collect radioactive carbon dioxide if large gas or vapor releases are anticipated. This is to reduce the release to the environment.

3. Monitor surfaces routinely and keep records of the results. Geiger counters are sensitive to the beta radiation from 14 C if the probe is used within a 1/2 inch of the surface and the proper probe is used. Radiation Safety recommends a pancake type probe and a meter with a linear scale. With such a probe very low amounts of 14 C may be detected on a surface. Average efficiency for 14 C with a pancake probe is approximately 3%. Do not cover the pancake probe with saran wrap® or parafilm®, etc. when using the probe to monitor for 14 C. This practice will decrease the efficiency of detection. Wipe tests should be taken and counted in a liquid scintillation counter for the most sensitivity when detecting removable surface contamination.

4. Radiation badges are not issued for individuals using 14 C as the badge is very unlikely to detect any radiation because of the short beta range in air.

^{14}C LAB INFO SHEET

^{14}C Carbon

Low Energy Beta Emitter
Half-Life: 5730 Years
Max energy: 156 KeV (at 100%)
Max range in air: 8.6 in
ALI = 2 mCi (Ingestion/Inhalation)
Critical Organ: Whole Body
Bioassay: Urine

Detection: GM or LSC
GM meter w/Pancake probe (5-8%) efficient
LSC: (85-95%) efficient

Shielding: None Required

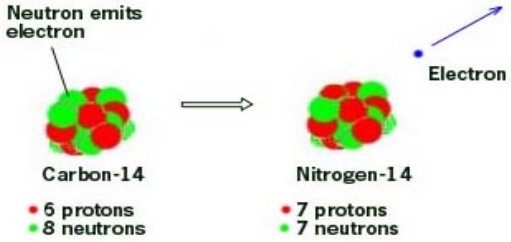
PPE : Double gloves, Lab coat, Safety glasses

Dosimetry: None Needed

LSC

Notes and Special Precautions

- **Liquid Scintillation Counter (LSC) efficiencies for ^{14}C= 85-95 % - RECOMMENDED.**
- **Use a Pancake GM for personal post experimental surveys, but note; efficiency is poor (5-8%). Survey technique should be slow and close to the surface without touching.**
- **Keep in mind that even a few counts above background (bkg) means it is likely that counts are real.**
- **Very long half-life - 5730 Years. If clothing or shoes become contaminated, items will have to be taken for proper disposal. Please wear proper PPE.**
- **Expensive to purchase and to dispose of. Please order only necessary quantities.**



Class IV Waste ≥ 120 days—Can be combined with ^{3}H

EMERGENCY SPILLS or SKIN CONTAMINATION

785-3555

Or 911 after hours

Yale *Environmental Health & Safety* *785-3550*

NO EATING, DRINKING, OR SMOKING in lab.

Phosphorus-32 (32 P) safety information and specific handling precautions

General:

Phosphorus-32 is an energetic beta emitter which can penetrate up to 0.8 cm into living skin tissue. Therefore, this isotope poses an external (skin) dose hazard to persons as well as a potential internal hazard. An internal exposure may occur if an individual contaminates bare skin, accidentally ingests the material, splashes it into the eyes, or breathes it in the form of a gas or vapor. The bone is the critical organ for intake of 32 P transportable compounds. Although about 60% of ingested Phosphorus-32 is excreted within the first 24 hours, only 1% per day is excreted after the second or third day following ingestion. Dose evaluations will require knowledge of the approximate date and and time of exposure to the isotope. The external hazard of 32 P can be reduced by applying the principles of time, distance and shielding. The dose rate at the open combi-vial top containing 1 mCi of 32 P in 1 ml of liquid is roughly 26 rem/hour! Since this dose rate will not be attenuated significantly by air, shielding materials should be placed between the source and personnel to absorb most of the radiation.

Never work over an unshielded open container of 32 P. The best shield for a 32 P source is a material like lucite or plexiglass (about 1/2 inch thick), which will absorb the beta particles while generating little secondary radiation (Bremsstrahlung). For mCi amounts of 32 P, thin lead shielding (1/8 to 1/4 inch thickness) may be added to the exterior of the plexiglass shield to attenuate the higher intensity secondary radiation. However, thin sheets of lead should not be used alone to shield 32 P. In addition, the less time spent near a radiation source of 32 P, the lower the exposure.

A high local skin dose can be received if the radioactive material is touched and allowed to remain on the skin or gloves. An amount of 1 uCi of 32 P deposited in 1 cm 2 area of bare skin would exceed the NRC annual skin exposure limit in less than eight hours. The face, eyes and hands can receive considerable exposure from an open container of 32 P, particularly if the radioactivity is in a concentrated form. The eye itself may receive a high local dose as well as providing a pathway into the body. The eyes should be protected from 32 P by wearing safety glasses. Safety goggles will prevent splashes from getting into the eyes and will also act as shielding for the eyes. The distance between yourself and a 32 P source can be easily increased by using remote handling devices such as tongs or forceps. This safe handling technique of using distance can substantially reduce exposure from 32 P.

Physical Data:

Maximum beta energy:1.71 MeV, 100% emission.
Maximum range in air: 18 to 20 feet.
Radiological half-life: 14.29 days.
Internal Occupational Limits:
Annual Limits on Intake-
Inhalation: 0.9 mCi
Ingestion: 0.6 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes.

2. Perform dry runs and practice routine operations to improve dexterity and speed before using 32 P.

3. Avoid skin exposure by using tools to indirectly handle unshielded sources and potentially contaminated vessels.

4. Traps may be necessary to collect 32 P if large gas or vapor releases are anticipated. This is to reduce the release to the environment.

5. Monitor surfaces routinely and keep records of the results. Geiger counters with a pancake probe should be used for 32 P radiation. Average efficiency for detecting 32 P with a pancake probe is 30%. Use wipe tests and a Liquid Scintillation Counter to determine levels of removable 32 P contamination.

6. Do not work over open containers of 32 P without shielding. Work with plexiglass shields (1/4 to 1/2 inch thickness). Shield all stock vials of 32 P. Do not use thin sheets of lead to shield 32 P.

7. Radiation badges are issued for individuals working with significant activities of 32 P. Individuals working with 10 mCi or greater will be issued an extremity dosimeter. Wear, store and return radiation badges as instructed by Radiation Safety.

^{32}P LAB INFO SHEET

ALARA: Time—Distance—Shielding. NO EATING, DRINKING, OR SMOKING in lab.

^{32}P Phosphorus

High Energy Beta Emitter
Half-Life: 14.29 days
Max energy: 1710 KeV (at 100%)
Max range in air: 18-20 ft
ALI: .9 mCi via inhalation
.6 mCi via ingestion
Critical Organ: Whole Body
Bioassay: Urine

Detection: GM or LSC
GM meter w/Pancake probe
(20-35%) efficient
LSC (90-95%) efficient

LSC

Shielding: 3/8" plastic, Plexiglas®

PPE: Double gloves,
Lab coat, Safety glasses

Dosimetry: Film Badge or TLD

Notes and Special Precautions

- **Skin dose main external hazard. Call EHS if skin is contaminated. High skin dose can occur in a short period of time. For example - 1 µCi on skin for 8 hrs = over NRC ANNUAL skin dose limit of 50,000 mrem. Personal surveys are vital.**
- **Use of safety glasses is important when working with ^{32}P. Safety glasses serve as a radiation shield against the ^{32}P betas as well as providing splash protection.**
- **Wear double gloves and change gloves often.**
- **Max Beta Energy = 1710 KeV: These high energy betas can penetrate into tissue – but only 0.8cm – so not a whole body dose. Only skin and eyes are at risk of an external exposure.**
- **Ring badges issued for users of 10 mCi or more.**
- **Plexiglas shielding (3/8 in.) is very effective.**
- **Short half-life -14.3 Days. If clothing items become contaminated, items may be returned after 12 half-lifes.**
- **Shielding note: DO NOT use lead to shield ^{32}P as high energy betas in lead can generate bremsstrahlung radiation (x-ray).**

Class I Waste < 15 days

EMERGENCY SPILLS or SKIN CONTAMINATION

785-3555

Or 911 after hours

Yale *Environmental Health & Safety* *785-3550*

Sulfur-35 (35 S) safety information and specific handling precautions

General:

Sulfur-35 is a low energy beta emitter and even large amounts of this isotope pose no external dose hazard to persons exposed. The beta radiation barely penetrates the outer protective dead layer of the skin of the body. The major concern for individuals working with this isotope is the possibility of an internal exposure. Such an exposure may occur if an individual contaminates bare skin, accidentally ingests the material, or breathes it in the form of a gas or vapor. The critical organ for most 35 S labelled compounds is the whole body. Urine analysis is an effective sampling technique to determine if a 35 S uptake has occurred.

Some 35 S labelled compounds may migrate through gloves and skin. 35 S compounds should be handled with gloved hands, and in some cases, with double gloves. Change gloves often. One should be careful not to contaminate the skin as some 35 S beta particles penetrate the dead layer of the epidermis. Some 35 S compounds may be incorporated in the skin causing very large skin doses and a pathway into the body. Certain forms of 35 S (methionine, cysteine and Translabel®) are volatile. Use a hooded enclosure, when possible, while handling volatile forms of 35 S. Activated charcoal is effective in helping to trap volatile species.

Physical Data:

Maximum beta energy: 0.167 MeV, 100% emission
Maximum range in air: about 9.6 inches
Radiological half-life: 87.4 days
Internal Occupational Limits:
Annual Limit on Intake-
Inhalation: 20 mCi
Ingestion: 8 mCi.

Precautions:

1. Follow General Safety Precautions for all isotopes.

2. Traps may be necessary if large gas or vapor releases are anticipated. This is to reduce the release to the environment. It may be necessary to incorporate activated charcoal into experiments involving volatile forms of 35 S.

3. Monitor surfaces routinely and keep record of the results. Geiger counters are sensitive to the beta radiation from 35 S if the probe is used within a 1/2 inch of the surface and the proper probe is used. The Radiation Safety Section recommends a pancake type probe and a meter with a linear scale. With such a probe very low amounts of 35 S may be detected on the surface. Average efficiency for 35 S with a pancake probe is approximately 8%. Do not cover the pancake probe with saran wrap® or parafilm®, etc. when using the probe to monitor for 35 S. This practice will decrease the efficiency of detection. Wipe tests should be taken and counted in a Liquid Scintillation Counter for the most sensitivity when detecting removable surface contamination.

4. Radiation badges are not issued for individuals using 35 S because it is very unlikely that any radiation exposure would be recorded because of the 35 S betas short range in air.

5. Proper tubes should be used for storage of single use aliquots of volatile 35 S material. Screw top tubes with rubber seals are recommended.

^{35}S LAB INFO SHEET

ALARA: Time—Distance—Shielding.

NO EATING, DRINKING, OR SMOKING in lab.

^{35}S Sulfur

Low Energy Beta Emitter
Half-Life: 87.4 days
Max energy: 167 KeV (at 100%)
Max range in air: 9.6 in
ALI: 20 mCi via inhalation
8 mCi via ingestion
Critical Organ: Whole Body
Bioassay: Urine

Detection: GM or LSC
GM meter w/Pancake probe
(5-8%) efficient
LSC: (85-90%) efficient

LSC

Shielding: None Required

PPE: Double gloves,
Lab coat, Safety glasses

Dosimetry: None Needed

Notes and Special Precautions

- **Use a Pancake GM for personal post experimental surveys, but note; efficiency is poor (5-8%). Survey technique should be slow and close to the surface without touching.**
- **Some chemical forms volatile...**
  (Methionine/Cysteine, Translabel®, ProMix, Invitro cell labeling mix)
  - **Activated charcoal is effective in helping trap volatile species.**
  - **Incorporate activated charcoal and single use aliquots.**
  - **Vent/open stock vials in a fume hood.**
  - **Surveys of incubators and waterbaths are important.**
  - **Use a hooded enclosure when possible.**
- **Wear double gloves and changes gloves often.**
- **Large quantities (>10 mCi) stored at –80 can cause local contamination of freezer. Larger stock vials should be placed in a secondary storage container and activated charcoal should be incorporated into container.**

Class III Waste ≥ 60 days ≤120 days

EMERGENCY SPILLS
or
SKIN CONTAMINATION

785-3555
Or 911 after hours

Yale *Environmental Health & Safety* *785-3550*

Iodine 125-I (125 I) safety information and specific handling precautions

125 I is considered toxic because of its affinity for the thyroid gland. Accordingly, allowable air and water concentrations are extremely low, making it extremely important that the release of radioiodine in the laboratory be controlled. Unbound radioiodine is extremely volatile and must be handled appropriately. Radioiodine is biologically active, and up to 30% of any activity ingested may concentrate in the thyroid gland. The maximum permissible levels of contamination in non-ventilated areas are well below the detection limit for a typical Geiger counter. Therefore, a thin crystal sodium iodide detector is recommended. Average efficiency for detecting 125 I with a sodium iodide probe is approximately 30%. 125 I decays with a half-life of 60 days. It emits soft gamma radiation and x-rays with a maximum energy of about 35 KeV; also emitted are conversion and auger electrons with a maximum energy of about 35 KeV. Radioiodine metabolized by the thyroid gland has an effective half-life in the thyroid gland of about six weeks.

Physical Data:

Maximum gamma radiation energy: 35 KeV
Maximum range in air: N/A
Radiological half-life: 60 days
Internal Occupational Limits:
Annual Limits on Intake:
Inhalation: .06 mCi
Ingestion: .04 mCi

Precautions:

1. Follow General Safety Precautions for all isotopes.

2. Use forceps fitted with rubber sleeves to ensure a secure grip on containers.

3. Radiation badges should be worn by all personnel involved in performing iodinations.

4. Radiation Safety approved hoods must always be used when performing iodinations.

5. Never remove the rubber vial septum on containers of volatile iodine! Remove all Na 125 I aliquots with Hamilton® hypodermic syringes inserted through the vial's rubber septum. The stock vial containing Na 125 I should be purged with a charcoal trap before beginning the experiment. The Radiation Safety Section can supply you with charcoal traps.

6. If the iodination procedure requires a vacuum withdrawal of supernate or other substance containing iodine, an iodine trap should be placed between the collection flask and the vacuum source in order to protect the house vacuum line from contamination.

7. Store Na 125 I solutions at room temperature in a approved hood, do not freeze and avoiding heat Na 125 I solutions as this will result in subsequent volatilization.

8. Maintain a pH greater than 7 in Na 125 I solutions in order to reduce volatilization.

9. Have reducing agents available when using Na 125 I.

10. In the event of a spill involving volatile Na 125 I hold your breath and vacate the iodination area closing the doors behind you. Do not permit anyone to enter the spill area and contact the Radiation Safety Section immediately.

11. More information pertaining to thyroid counts may be obtained by calling 737-2139 or 785-4250. Thyroid counts are scheduled as required and performed in BCMM B-01.

^{125}I LAB INFO SHEET

^{125}I Iodine

Low Energy Gamma Emitter
Half-Life: 60 days
Max energy: 35KeV (at 100%)
ALI: .06 mCi via inhalation
.04 mCi via ingestion
Critical Organ: Thyroid
Bioassay: Thyroid count

Detection:
Meter w/ NaI Probe
Gamma Counter, LSC

Shielding: Lead

PPE: Double gloves,
Lab coat, Safety glasses

Dosimetry: Film Badge or TLD



LSC

Gamma Counter


Notes and Special Precautions

- **Personal surveys are vital.**
- **Use NaI probe for direct survey. NaI probes are very sensitive. Note: Bkg ~ 300cpm —GM Probes are NOT efficient ~ only at .07%.**
- **Wear double gloves and change gloves often.**
- **Toxic due to affinity for thyroid gland.**
- **Lead shielding and badges for mCi quantities.**
- **Careful of following issues which can increase volatility;**
  - **Do not freeze ^{125}I,**
  - **Keep pH of iodine materials basic,**
  - **Do not use bleach to deactivate waste, use iodine based disinfectant instead.**

Precautions specific to use 1) RIA Kit users and 2) Free Iodinations

- **RIA Kit users –dosimetry is NOT required, low amounts to work with (µCi) Work can be done on benchtop. Shielding liquid waste is recommended.**
- **Iodinations require more controls because unbound Iodine (NaI) is volatile (Air Sampling required) Approved iodination hoods required (BCMM Lab) for iodinations.**
  - **Thyroid counts required for iodinators (Done in BCMM B01).**
  - **Baseline and then within 6-72 hours post each iodination.**
  - **Call 785-4250 for EHS iodination scheduling.**

Class III Waste ≥ 60 days ≤120 days

EMERGENCY SPILLS or SKIN CONTAMINATION

785-3555

Or 911 after hours

Yale *Environmental Health & Safety* *785-3550*

ALARA: Time—Distance—Shielding.

NO EATING, DRINKING, OR SMOKING in lab.

There are two supervised labs available for radioactive iodinations. They are located at 1138 KBT and B-01 BCMM. These laboratories are equipped with protective matting, charcoal traps, fume hoods, air sampling apparatus and other laboratory equipment. All iodinations should be performed in one of these laboratories unless an alternative fume hood has been approved for iodinations by the Radiation Safety Section. Use of these laboratories is available by appointment by calling 737-2139 or 785-4250.

Thyroid counts should be obtained by all individuals prior to working with radioactive iodine. Thyroid counts are also required for those individuals performing iodinations 6 to 72 hours post each iodination. Quarterly thyroid counts may be required for individuals who work with iodine but do not actually perform iodinations.