

Hydrogen - 3

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

BETA ENERGIES

- 18.6 keV (maximum)
 - 5.7 keV (average) (100%)
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Physical Half-Life	12.3 years
Biological Half-Life	10 -12 days
Effective Half-Life	10 -12 days *

* Forcing liquids to tolerance (3-4 liters/day) will reduce the effective half-life of H-3 by a factor of 2 or 3. (Relatively easy to flush out of system with fluids).

Specific Activity	9650 curies/gram
Maximum Beta Range in Air	5 mm = 0.5 cm = 1/4"
Maximum Beta Range in Water	0.005 mm = 0.0005 cm = 3/10,000"
Penetrability of Beta Particle in Matter or Tissue	Insignificant *

* 0% of beta particle energy transmitted through dead layer of skin

Shielding

None required

Volatility

Inherent Volatility (at STP): **Substantial**

Organic compounds of H-3 are not very volatile under normal circumstances and the probability of their being inhaled as vapors is, therefore, small.

Exposure: Radiological Safety Information

Rule of Thumb: 0.001 uCi/liter of H-3 in urine sample is indicative of a total integrated whole body dose of approximately 10 millirem (average person) if no treatment is instituted (flush with fluids) (NCRP-65/1980)

- Experimental uses include total body water measurements and in-vivo labeling of proliferatory cells by injection of tritium-labeled compounds (ie: thymidine). Tritium labeling is also used in a variety of metabolic studies.

- Oxidation of H-3 gas in air is usually slow (< 1% per day)
- Absorption of H-3 inhaled in air is much less when it is present as elemental H-3 than as tritiated water (HTO).
- Tritium penetrates the skin, lungs, and GI tract either as tritiated water or in the gaseous form.
Exposure Prevention: Radiological Safety Information.
- Tritiated water, taken into the body by inhalation, ingestion, or absorption through the skin is assumed to be completely and instantaneously absorbed and rapidly mixed with total body water.
- Ingested tritiated water is assumed to be completely and instantaneously absorbed from the GI tract and to mix rapidly with the total body water so that, at all times following ingestion, the concentration in sweat, urine, sputum, blood, insensible perspiration, and expired water vapor is the same.
- Tritiated water is instantaneously distributed uniformly among all the soft tissues of the body after inhalation.

Exposure Prevention: Radiological Safety Information

- **Always** wear a lab coat and disposable gloves when handling H-3.
- Forcing fluid reduces internal exposures from H-3.

Regulatory Compliance Limits (10 CFR 20/Appendix B)

REGULATION	UNIT OF MEASURE	NOTE
Derived Air Concentration (DAC)	2.0E-5 uCi/mL (occupational)	
Airborne Effluent Release Limit (Annual Average)	1.0E-7 uCi/mL	Applicable to the assessment and control of dose to the public (10 CFR 20.1302). If this concentration were inhaled continuously for over a one-year period the resulting TEDE would be 50 millirem.
Unrestricted Area Removable Contamination Limit	1,000 dpm/100 cm ²	
Container Labeling Quantity (10 CFR 20.1905)	≥ 1,000 uCi	
Urinalysis	license requirement when handling ≥ 100 mCi H-3	

Annual Limit on Intake (ALI)

- 80 mCi (ingestion or inhalation) [H₃O]
 - 1.0 ALI = 80 mCi (H-3) ingested or inhaled = 5,000 mrem CEDE
- For a continuous inhalation exposure at a rate of 1/365 of an ALI per day, the equilibrium concentration of H-3 in urine is 0.073 uCi/ml.
NOTE: 1/365 of 80 mCi (ALI) = 219 uCi
- The ingestion ALI of tritiated thymidine is likely to be approximately 1/10 of that for tritiated water.
- The ALI for tritiated thymidine might be as much as 50-times smaller than the ALI for tritiated water

Contamination

Least radiohazardous of all radionuclides.

Radiological Data

Critical Organ	Body Water or Tissue
Routes of Intake	<ul style="list-style-type: none">• Ingestion• Inhalation• Puncture• Wound• Skin Contamination (Absorption)
External exposure (deep dose) from weak H-3 beta energy	Is not a concern
Internal exposure and contamination are primary radiological concerns.	Committed Dose Equivalent (CDE) (inhalation, ingestion, or puncture) <ul style="list-style-type: none">• 64 mrem/mCi Committed Effective Dose Equivalent (CEDE) <ul style="list-style-type: none">• 64 mrem/ mCi

Skin Contamination (H-3)

- Skin contamination, ingestion, inhalation, and punctures involving H-3 are primary radiological concerns (internal doses).
- Skin Contamination Exposure Rate — 57,900 mrad/h per 1.0 mCi (contact)
- Exposure rate to 'dead layer of skin' (< 0.007 cm depth) only
- Skin contamination of $1.0 \text{ uCi/cm}^2 = 0 \text{ mrad/h}$ dose rate to basal cells

Internal Contamination

- As gaseous hydrogen, H-3 is not significantly absorbed into the body and does NOT exchange significantly with hydrogen in the body compounds.
- As water (HTO), the H-3 entering the lung or GI tract is completely absorbed and is rapidly dispersed throughout the body.
- Some H-3 is incorporated into cellular components and has a long turnover rate.
- The volume of total body water (standard man) is 42,000 ml.
- The concentration of H-3 (uCi/ml) in urine is assumed to be the same as that in total body water. (urine concentration = body concentration)
- The predicted concentration activity normalized to unit intake from inhalation is $2.204\text{E-}5 \text{ uCi/ml}$ per uCi of H3 intake.
- Tritiated thymidine, if not catabolized, is taken up only by the nuclei of those cells synthesizing DNA.

Detect Contamination

- Detection Limit of H-3 in Urine: $1.08E-5$ uCi/ml (approximately).

Survey Instrumentation

- Monitor for H-3 contamination using only smears, swabs, swipes, or wipe testing (bench tops, floors, refrigerator/freezer handles, phone, etc).
- H-3 **cannot** be detected using a G-M or NaI survey meter
- Use Liquid scintillation counter (indirect) only to detect H-3 contamination on smears or swipes [LSC counting efficiency (max): 50% (full window)]

Required Personal Radiation Monitoring

Dosimeter (Whole Body Badge or Finger Rings): Not Needed (H-3 beta energy is too weak)