Sulphur - 35

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

BETA ENERGIES
• 167 keV (maximum)
• 49 keV (average)(100%)

Physical Half-Life	87.1 days	87.1 days
Biological Half-Life	623.0 days (testes)	90.0 days (total body)
Effective Half-Life	76.6 days (testes)	44.3 days (total body)

Specific Activity	42,707 curies/gram

Maximum Beta Range in Air	26.00 cm = 10.500"
Maximum Beta Range in Water/Tissue	0.04 cm = 0.015"
Maximum Range in Plexiglas or Lucite	0.25 mm = 0.010"

- Fraction of S-35 betas transmitted through dead layer of skin = 17%
- Fraction of S-35 betas transmitted to lens-of-the-eye = 0%

Shielding

None Required (≤ 3 mm plexiglass)

Half-Value Layer (HVL)	0.0053 cm = 0.053 mm
Tenth-Value Layer (TVL)	0.0180 cm = 0.180 mm

Volatility

- Inherent volatility (STP): Significant for S-35 methionine and cysteine
- Radiolysis of S-35 amino acids (cysteine and methionine) during storage and use may lead to the release of S-35 labeled volatile impurities. Volatile impurities are small (≤ 0.05%).
- The volatile components of S-35 labeled cysteine and methionine are presumed to be hydrogen sulfide (H2S) and methyl mercaptan (CH3SH), respectively.

Exposure: Radiological Safety Information

Exposure Rates

Exposure rate from a 1 millicurie unshielded isotropic point source of S-35:

DISTANCE	RAD/HOUR
1.0 cm	1173.6
2.5 cm	93.7
15.24 cm	0.2
20 cm	0.01

Exposure Prevention

- **Always** wear a lab coat and disposable gloves when handling S-35
- Inhalation of the gases SO2, COS, H2S, and CS2 must be considered. Sulfur entering the lungs in these forms is completely and instantaneously translocated to the transfer compartment and from there its metabolism is the same as that of sulfur entering the transfer compartment following ingestion or inhalation of any other organic compound of sulfur.

Engineering Controls

- Vials of S-35 labeled amino acids (cysteine and methionine) should be opened and used in ventilated enclosures (exhaust hoods). In addition, S-35 vapors may be released when opening vials containing labeled S-35 amino acids, during any incubating of culture cells containing S-35, and the storage of S-35 contaminated wastes.
- Radiolytic breakdown may also occur during freezing process, releasing as much as 1.0 uCi of S-35 per 8.0 mCi vial of S-35 amino acid during the thawing process.
- S-35 labeled amino acids work should be conducted in an exhaust hood designated for radiolytic work.
- Vent S-35 amino acid stock vials with an open-ended charcoal-filled disposable syringe. Activated charcoal has a high affinity for S-35 vapors.
- Place an activated carbon or charcoal canister, absorbent sheet, or tray (50-100 grams of granules evenly distributed in a tray or dish) into an incubator to passively absorb S-35 vapors. Discard absorbers which exhibit survey meter readings of > 10-times facility background levels.
- Expelling S-35 solutions through syringe needles and pipette tips can generate airborne aerosols. • Drying can cause airborne S-35 dust contamination and rapid boiling can volatilize S-35 or cause airborne S-35 aerosol contamination.

Personal Safety

- Metabolic behavior of organic compounds of sulfur (cysteine and methionine) differs considerably from the metabolic behavior of inorganic compounds.
- Organic compounds of sulfur (cysteine and methionine) become incorporated into various metabolites. Thus, sulfur entering the body as an organic compound is often tenaciously retained.
- The fractional absorption of sulfur from the gastrointestinal tract is typically > 60% for organic compounds of sulfur. Elemental sulfur is less well absorbed from the GI tract than are inorganic

compounds of the element (80% for all inorganic compounds of sulfur and 10% for sulfur in its elemental form). Elemental sulfur is an NRC inhalation Class W.

Regulatory Compliance Limits (10 CFR 20/Appendix B)

REGULATION	UNIT OF MEASURE	NOTES
Derived Air Concentration (DAC): Occupational	• 6.0E-6 uCi/mL(S-35 vapors) • 7.0E-6 uCi/mL(sulfide/sulfate) • 9.0E-7 uCi/mL(elemental sulfur)	
Airborne Effluent Release Limit (Annual Average)	• 2.0E-8 uCi/mL (S-35 vapors) • 2.0E-8 uCi/mL (sulfide/sulfates) • 3.0E-9 uCi/mL (elemental sulfur)	
Urinalysis	Not Required.	However, may be requested by RSS after a radioactive spill involving S-35 or suspected intake. Recommended after working with > 10 mCi of S-35
Unrestricted Area Removable Contamination Limit	≤ 1,000 dpm/100 cm^2	
Container Labeling Quantity (10 CFR 20.1905)	≥ 100 uCi	

Annual Limit on Intake (ALI)

- 10 mCi (ingestion: sulfides/sulfates/LLI)
- 6 mCi (ingestion: elemental S-35/WB)
- 8 mCi (ingestion: sulfides/sulfates/WB)
- 10 mCi (inhalation: S-35 vapors/WB)
- 20 mCi (inhalation: sulfides/sulfates/WB)
- 2 mCi (inhalation: elemental S-35/WB)

1.0 ALI = 10 mCi (inhaled S-35 vapors) = 5,000 millirem CEDE/WB

1.0 ALI = 8 mCi (ingestion sulfides/sulfates LLI) = 50,000 mrem CDE

Contamination

Contamination of internal surfaces of storage and reaction vessels may occur (rubber o-rings).

Radiological Data

Critical Organ	Testis
Routes of Intake	• Ingestion • Inhalation • Puncture • Wound • Skin Contamination (Absorption)
External exposure (deep dose) from weak S-35 beta particles is not a radiological concern.	Radiation monitoring dosimeters not needed.
Internal exposure and contamination are primary radiological concerns.	Committed Dose Equivalent (CDE): (LLI Wall/Sulfides/Sulfates): • 5.00 millirem/uCi (ingested) • 0.352 millirem/uCi (puncture) Committed Effective Dose Equivalent (CEDE): • 0.6256 mrem/uCi (ingested) o Assumes a 90-day biological half-life

Skin Contamination (S-35)

- Skin contamination (dose), ingestion, inhalation, puncture/injection, absorption through skin, and area contamination are primary radiological safety concerns.
- Skin Contamination Dose Rate: 1,139 millirem/hour per 1.0 uCi/cm^2
  - Dose to Basal Cells at a tissue depth of 7 mg/cm^2 or 0.007 cm without air reflection
- Skin Contamination Dose Rate (Extremities): S-35 betas cannot penetrate 30 mg/cm^2 (0.3 cm) tissue

Detect Contamination

Excessive contamination can be noted on the inside surfaces and in water reservoirs of incubators used for S-35 work. Most notable surface contamination can be found on rubber seals of incubators and centrifuges.

Survey Instrumentation

- Monitor for removable surface contamination by smearing, swiping, swabbing, or wipe testing where S-35 is used. Count smears or swabs in a liquid scintillation counter (LSC).
- Monitor personnel (hands, clothing, shoes, etc), work areas, and floors using a G-M survey meter equipped with a G-M pancake/frisker probe for gross contamination.
- Can detect S-35 using a thin-window G-M survey meter; however, survey meter probe must be at close range (≤ 1 inch).
- G-M survey meter equipped with a pancake/frisker (15.5 cm^2 area) has a very low counting efficiency (4%).
- Liquid scintillation counter (indirect counter) should be used to detect removable S-35 contamination on smears, swipes, swabs, etc.

Required Personal Radiation Monitoring

- Dosimeters (Whole Body Badge or Finger Tabs): Not Needed (S-35 beta particle energy is too weak).
- A urinalysis should be conducted by an RSS Health Physicist after researchers have worked with > 10 millicuries of S-35 amino acids