

## Tchnetium - 99m

### Radiological Safety Guidance

Revision Date: 09/20/18

## Physical Data

### GAMMA ENERGIES

- 140.51 keV (89.1% abundance)
- 18.37 keV (4.0%)
- 18.25 keV (2.1%)

No beta particles emitted by Tc-99m

|                                    |   |
|------------------------------------|---|
| <b>Specific Gamma Ray Constant</b> | 0.076 mrem/h at 1 meter per 1 mCi, or<br>760 mrem/h at 1 cm per 1 mCi   |
| <b>Physical Half-Life</b>          | 6.02 hours  |
| <b>Biological Half-Life</b>        | 24.00 hours   |
| <b>Effective Half-Life</b>         | 4.80 hours  |
| <b>Specific Activity</b>           | 5,243,820 curies/gram ("carrier free"/pure Tc-99m)<br>3.4 x 10 <sup>6</sup> curies/gram (99m Tc-pertechnetate form) |

### Shielding

¼" – ½" lead shielding is adequate for Tc-99m 140 keV gammas

| SHIELDING                              | THICKNESS                     |
|--|-------------------------------|
| Half-Value Layer (HVL/Lead)            | 0.027 cm = 0.011 in (140 keV) |
| Half-Value Layer (HVL/Water or Tissue) | 4.60 cm = 1.81 in             |
| Tenth-Value Layer (TVL/Lead)           | 0.083 cm = 0.033 in (140 keV) |
| Tenth-Value Layer (TVL/Concrete)       | 6.60 cm = 2.60 in             |
| Attenuation Coefficient (100)          | 0.16 cm = 0.063 in (lead)     |
| Attenuation Coefficient (1000)         | 0.25 cm = 0.104 in (lead)     |

### Volatility

Inherent Volatility (STP): Insignificant/Negligible

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## Exposure: Radiological Safety Information

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- **Technetium-99m**, in the form of **sodium pertechnetate** ( $\text{Na}^{99\text{m}}\text{TcO}_4$ ), is easily obtained from a  $^{99}\text{Mo}$ - $^{99\text{m}}\text{Tc}$  ("molly") generator. Typical dose administered is 10 mCi via ingestion (GI Tract Stomach Wall: 51 mrem/mCi, Thyroid: 1300 mrem/mCi, Upper Large Intestine Wall: 120 mrem/mCi). Imaging time is typically 30-minutes after administration. Moly-generators are generally replaced weekly in the UMH Nuclear Pharmacy.
- **Technetium-99m pertechnetate** ( $^{99\text{m}}\text{TcO}_4$ ) is obtained directly from the "molly" generator using saline as the eluting solution. This radiopharmaceutical is used for brain, thyroid, salivary gland, and stomach scanning. Typical adult dose is 15 millicuries.
- Separation of daughter Tc-99m from parent Mo-99 is usually accomplished by eluting a moly-generator with sterile normal saline solution.
- **Tc-99m Pertechnetate**: brain, thyroid, stomach, salivary gland scans
- **Tc-99m Sulfur Colloid**: liver imaging (delivered intravenous dose: 1-8 mCi (3 mCi)/338 mrad/mCi/imaging time is 30-minutes after injection); spleen imaging (delivered intravenous dose: 1-8 mCi/213 mrad/mCi), and bone marrow scans (delivered intravenous dose: 3-12 mCi/27.5 mrem/mCi). Oral administration doses are generally 500 uCi.
- **Tc-99m Macroaggregated Albumin** ( $^{99\text{m}}\text{Tc}$  MAA): lung scans; typical administered dose is 3 mCi Tc99m/injection; imaging time is within 2-3 minutes; lung imaging dose (22 mrad/mCi).

### Exposure Rates

Exposure rates from unshielded 1.0 millicurie isotropic point source of Tc-99m:

| DISTANCE  | MILLIREM/HOUR |
|-----------|---------------|
| 1.0 cm    | 760.00        |
| 10.00 cm  | 7.60          |
| 100.00 cm | 0.076         |
| 6.0 in    | 3.270         |

### Exposure Prevention

Always wear a lab coat and disposable gloves when handling Tc-99m.

### Engineering Controls

- Drying can cause airborne Tc-99m dust contamination.
- Rapid boiling can cause airborne Tc-99m aerosol contamination.
- Expelling Tc-99m solutions through syringe needles and pipette tips can generate airborne aerosols.

### Personal Safety

- Tc-99m is used in clinical and research diagnostic scanning and imaging.
- Whole body and extremity exposures, skin contamination (dose), ingestion, inhalation, puncture/injection, absorption through skin, and area contamination are primary radiological safety concerns.

## Regulatory Compliance Limits (10 CFR 20/Appendix B)

| REGULATION                                       | UNIT OF MEASURE  | NOTES   |
|--|--|---|
| Derived Air Concentration (DAC) (Occupational)   | 6.0E-5 uCi/mL (Class "D")<br>1.0E-4 uCi/mL (Class "W") |   |
| Airborne Effluent Release Limit (Annual Average) | 2.0E-7 uCi/mL (Class "D")<br>3.0E-7 uCi/mL (Class "W") | Applicable to the assessment and control of dose to the public (10 CFR 20.1302). If this concentration was inhaled continuously for over one year the resulting TEDE would be 50 millirem |
| Unrestricted Area Removable Contamination Limit  | 1,000 dpm/100 cm <sup>2</sup>                          |   |
| Container Labeling Quantity (10 CFR 20.1905)     | ≥ 1 mCi  |   |

### Annual Limit on Intake (ALI)

- 80 mCi (all compounds)\* (oral ingestion/CEDE/Whole Body/5 rem)
  - 1.0 ALI = 80 mCi ingested = 5,000 millirem CEDE/Whole Body

\* (all compounds, except oxides hydroxides, halides, and nitrates)

- 200 mCi (all compounds) (inhalation/CEDE/WB/5 rem/Class "D")
- 200 mCi (all compounds) (inhalation/CEDE/WB/5 rem/Class "W")
  - 1.0 ALI = 200 mCi inhaled = 5,000 millirem CEDE/WB/Class "D"

## Contamination

### Radiological Data

|  |   |
|--|---|
| Critical Organ (Biological Destination)*                         | Total Body  |
| Routes of Intake   | <ul style="list-style-type: none"> <li>• Ingestion</li> <li>• Inhalation</li> <li>• Puncture/Injection</li> <li>• Wound</li> <li>• Skin Contamination (Absorption)</li> </ul>   |
| External and internal exposure and contamination concerns Tc-99m | Committed Dose Equivalent (CDE): (Organ Doses) <ul style="list-style-type: none"> <li>• 0.407 mrem/uCi (puncture/thyroid/adult)</li> <li>• 0.313 mrem/uCi (ingestion/thyroid)</li> <li>• 0.186 mrem/uCi (inhalation/thyroid)</li> </ul> |

- Tc-99m Pertechnetate (99mTcO<sub>4</sub>) - (MUGA Scans) behaves similar to iodine and concentrates in thyroid, salivary glands, brain, blood pool, urinary bladder, and stomach. Stomach receives majority of dose and contains 25% of administered dose after 4 hours.

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- Tc-99m-Labeled Sulfur Colloid - approximately 70-80% of the administered dose (3 mCi/injected) is localized in the liver. Used for liver, spleen, and bone-marrow scanning.
  - Tc-99m-Labeled Macroaggregated Albumin (<sup>99m</sup>Tc MAA) - primarily used for lung scanning; 90-95% of administered dose (3mCi/injected) is trapped in the capillary bed of the lungs within a few seconds after intravenous administration.
  - Tc-99m (MUGA) - spleen receives approximately 2.6 rad/mCi. Tc-99m (DTPA) - brain or kidney scan; administered dose is 20 mCi (injected); bladder (0.5 rad/mCi); whole body (20 mrad/mCi)

### ***Skin Contamination (Tc-99m)***

- Skin Contamination Dose Rate (Basal Cells): 718 millirad/hour per uCi/cm<sup>2</sup>
  - Dose to basal cells at a depth of 7 mg/cm<sup>2</sup> or 0.007 cm in tissue without air reflection
- Skin Contamination Dose Rate (Extremity Skin): Negligible
  - Dose to skin of extremities at a tissue depth of 30-50 mg/cm<sup>2</sup> of 0.03 cm

## **Detect Contamination**

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### ***Survey Instrumentation***

- Monitor for removable surface contamination by smearing, swiping, swabbing, or wipe-testing where Tc-99m is used. Count smears or swabs in a liquid scintillation counter (LSC), gas proportional counter (GPC), or a gamma counter.
- Monitor personnel, work areas, and floors using a survey meter equipped with a 1" x 1" or a low-energy NaI scintillation probe for Tc-99m contamination. A survey meter equipped with a G-M pancake/frisker probe (15.5 cm<sup>2</sup> surface area) can be used for the detection of gross Tc-99m contamination.
- Survey meter equipped with a 1" x 1" or a low-energy NaI scintillation probe is preferred for the detection of Tc-99m contamination. Typical counting efficiencies: [1" x 1" NaI probe (39%)] and [low-energy NaI probe (12%/Ludlum and 18%/Bicron)].
- Survey meters equipped with a G-M pancake/frisker (15.5 cm<sup>2</sup> surface area) can be used; however, they exhibit very low counting efficiencies (approximately, 1.2%) for the detection of low-energy Tc-99m gamma rays. G-M probes are only effective for gross Tc-99m contamination.
- Indirect counting using a liquid scintillation counter (LSC), gamma counter, or gas proportional counter (GPC) should be used to detect removable Tc-99m contamination on smears, swabs, or swipes.

### ***Required Personal Radiation Monitoring***

Dosimeters (Whole Body and Finger Tabs): **Required** when handling > 1.0 millicurie of Tc-99m at **any** time.