ENVIRONMENT, HEALTH & SAFETY
UNIVERSITY OF MICHIGAN

Ruthenium - 103

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

GAMMA ENERGIES	BETA ENERGIES
• 497.1 keV (88.9% abundance)	• 226.0 keV (90.0% / maximum)
• 610.3 keV (5.6%)	• 63.2 keV (90.0% / average)
• 20-23 keV (6.3%) (complex of 3 gamma rays)	
	• 112.8 keV (6.4% / maximum)
	• 29.8 keV (6.4% / average)
	• 723.2 keV (3.5% / maximum)
	• 239.2 keV (3.5% / average)

- Beta particles with energies of 70 keV and 795 keV can penetrate the dead layer of skin and lens of the eye, respectively.
- Fraction of Ru-103 beta particles (226 keV) transmitted through the dead layer of skin (0.007 cm) is approximately 35%.

Physical Half-Life	39.35 days
Biological Half-Life	2.50 days (kidney) 7.3 days (total body)
Effective Half-Life	2.40 days (kidney) 6.2 days (total body)
Specific Gamma Constant	0.33 mrem/h at 1.0 meter per millicurie
Specific Activity	• 10.59 millicuries/gram (microspheres) • 32,166.00 curies/gram (solutions)
Maximum Beta Range in Air (226 keV)	43.18 cm = 17.00 in = 1.420 ft
Maximum Beta Range in Water (226 keV)	0.57 mm = 0.057 cm = 0.0225 in

Shielding

Half-Value Layer* (HVL / Lead)	5.0 mm = 0.50 cm = 0.2 in
Tenth-Value Layer** (TVL / Lead)	16.5 mm = 1.65 cm = 0.5 in

* Half-Value Layer (HVL) is the thickness of any given absorber or shield that will reduce the intensity of a radiation beam to 1/2 (50%) of its initial value.

** Tenth-Value Layer (TVL) is the thickness that will reduce the intensity of a radiation beam to 1/10 (10%) its initial value.

NOTE: Plexiglass, acrylic, plastic, wood or other low-density material will **not** shield Ru-103 gamma rays; use lead bricks.

Volatility

Inherent Volatility (STP): Insignificant / Negligible

Exposure: Radiological Safety Information

Exposure Rates

From an unshielded 1.0 millicurie isotropic point source of Ru-103.

DISTANCE	mrem/h
1.00 cm	3320.00
10.00 cm	33.20
100 cm	0.33
6.00 in	14.21

Exposure Prevention

Always wear a lab coat and disposable gloves when handling Ru-103.

Engineering Controls

- Microspheres behave like fine powders when dry and can result in airborne dust contamination if not handled properly; maintain microspheres suspended in solution whenever possible.
- Ru-103 is generally used in microsphere work (research animal surgery)
- Monodispersed Ru-103 microspheres are generally 10-15 micron in diameter
- Rapid boiling can cause airborne Ru-103 aerosol contamination.
- Confine procedures that can cause airborne contamination to ventilated enclosures such as exhaust hoods & glove boxes (DO NOT use biosafety or laminar flow hoods that exhaust back into laboratories!)
- Expelling Ru-103 solutions through syringe needles and pipette tips can generate airborne aerosols.
- In order to ensure a homogenous suspension of microspheres, Ru-103 microspheres will need to be physically shaken or vortexed. In addition, warm water helps suspend microsphere beads in more viscous solutions.
- Use high density (high Z) shielding material to shield Ru-103 (lead).
- Use remote handling tools when handling > 1 mCi of Ru-103 whenever possible.

Administrative Controls

- Sealed and plated sources of Ru-103 (> 100 uCi) MUST be leak-tested and inventories by RSS personnel once very 6 months.
- Research personnel must maintain a current inventory of Ru-103 sources at all times.

Personal Safety

- 10-15 micron diameter particles can be inhaled; however, are not considered respirable because they are too large to lodge in the lungs. Such microspheres will clear rapidly from the body via the GI.
- Microsphere suspensions are commonly handled by syringes. Syringes should be handled very carefully to avoid accidental self-injection.

Regulatory Compliance Limits (10 CFR 20 / Appendix B)

REGULATION	UNIT OF MEASURE	NOTES
Derived Air Concentration (DAC)	Occupational Inhalation Exposures • 7.0E-07 uCi/mL (Class "D" / all compounds except halides & oxides) • 4.0E-07 uCi/mL (Class "W" / inhalation / halides) • 3.0E-07 uCi/mL (Class "Y" / inhalation / oxides & hydroxides)	
Airborne Effluent Release Limit (Annual Average)	• 2.0E-09 uCi/mL (Class "D" / see above) • 1.0E-09 uCi/mL (Class "W" / halides) • 9.0E-10 uCi/mL (Class "Y" / see above)	Applicable to the assessment & control of dose to the public (10 CFR 20.1302). If this concentration was inhaled or ingested continuously over one year it would produce a TEDE of 50 millirem.
Unrestricted Area Removable Contamination Limit	1,000 dpm/100 cm^2	
Container Labeling Quantity (10 CFR 20.1905)	≥ 100 uCi	
Leak Tests (Sealed/Plated Sources > 100 uCi)	Semi-Annually	

Annual Limit on Intake (ALI)

- 2.0 mCi (all compounds / ingestion / CEDE / 5 rems to Whole Body)
  - 1.0 ALI = 2 mCi ingestion = 5,000 mrem CEDE (Whole Body) = 2,000 DAC-hrs
- 2.0 mCi (all compounds except halides / oxides / hydroxides / Class "D" / inhalation / CEDE / 5 rems to Whole Body)
  - 1.0 mCi (halides / inhalation / Class "W" / CEDE / 5 rems Whole Body)
  - 600 uCi (oxides & hydroxides / inhalation / Class "Y" / CEDE / WB)
  - 1.0 ALI = 1 mCi inhaled = 5,000 mrem CEDE (Whole Body) = 2,000 DAC-hrs

Contamination

Radiological Data

Critical Organ	Kidney
Routes of Intake	• Inhalation • Ingestion • Puncture • Wound • Skin Contamination (absorption)
External, internal, skin exposure and contamination are concerns	Committed Dose Equivalent (CDE) (Organ Doses) • 2.12 mrem/uCi (ingestion / gonad) • 0.61 mrem/uCi (ingestion/redbone marrow) • 3.70 mrem/uCi (inhalation/lung/Class "D") • 36.60 mrem/uCi (inhalation/lung/Class "W") 59.20 mrem/uCi (inhalation/lung/Class "Y")

Skin Contamination (Ru-103)

- Skin Contamination Beta Dose Rate: 1,984 mrem/hour per 1.0 uCi/cm^2 &
- Skin Contamination Gamma Dose Rate: 74 mrem/hour per 1.0 uCi/cm^2
  - Localized dose rate to basal cells at 7 mg/cm^2 or 0.007 cm depth in tissue with no air reflection
- Skin Contamination Beta Dose Rate: 42 mrem/hour per 1.0 uCi/cm^2
  - Localized dose rate to extremity skin at 30-50 mg/cm^2 or 0.03-0.05 cm depth

NOTE: Skin dose assessments must account for gamma dose to the skin as well as beta dose even though the gamma contribution will be small compared to the beta dose.

Detect Contamination

- Microspheres will not be significantly absorbed into body fluids because of their size and insolubility; therefore, it is NOT possible to detect an intake of Ru-103 microspheres by urinalysis.
- Nasal smears, whole body counting, or fecal analyses completed within approximately 24 hours after an intake will be the appropriate bioassay method.

Survey Instrumentation

- Monitor for removable surface contamination by smearing, swiping, swabbing, or wipe testing where Ru-103 is used. Count smears or swabs in a liquid scintillation counter (LSC), gamma counter, or gas proportional counter (GPC).
- Monitor personnel (hands, clothing, shoes, etc), work areas, and floors using a G-M survey meter equipped with a pancake / frisker or NaI scintillation probe for gross contamination.
- Survey meter equipped with a G-M pancake/frisker or standard cylindrical style G-M probes are quite efficient for the detection of Ru-103.
- Survey meter equipped with a 1"x1" or low-energy NaI scintillation probes will be very efficient for the detection of Ru-103; however, may be too sensitive and expensive for routine radiation monitoring work.
- Liquid scintillation counter (LSC), gas proportional counter (GPC), or gamma counters (indirect counting methods) should be used to detect removable surface contamination of Ru-103 on smears or swabs.

Required Personal Radiation Monitoring

- Dosimeters (Whole Body and Finger Tabs): **Required** when handling > 1.0 mCi of Ru-103 at **any** time.
- Urinalyses: Not Required; however, may be requested after a suspected intake. Ineffective for insoluble Ru-103 microspheres.
- Whole Body Bioassay: May be requested after suspected intake of insoluable Ru-103 microspheres.