ENVIRONMENT, HEALTH & SAFETY
UNIVERSITY OF MICHIGAN

Sodium - 22

Radiological Safety Guidance

Revision Date: 09/20/18

Physical Data

GAMMA ENERGIES
• 511.0 keV (179.8% abundance/annihilation)
• 1274.5 keV (99.9%)

BETA ENERGY [POSITRON (BETA$^+$)]
• 545.5 keV (89.8% abundance/maximum energy)
• 215.5 keV (89.8% abundance/average energy)

• 2842.1 keV (0.6% abundance/maximum energy)
• 834.8 keV (0.6% abundance/average energy)

Physical Half-Life	2.602 years
Biological Half-Life	11.0 days
Effective Half-Life	11.0 days
Specific Gamma Constant	1.2 mR/hour per millicurie at 1.0 meter
Specific Activity	6244 curies/gram
Maximum Beta Range in Air	56.0 inches
Maximum Beta Range in Water/Tissue	0.07 inch = 0.18 cm = 1.8 mm

- A beta particle with energy of 795 keV can penetrate to a depth of the lens of the eye (0.3 cm or 300 mg/cm^2).
- A beta particle with energy of 70 keV is required to penetrate the dead layer of skin (0.007 cm or 7 mg/cm^2).
- Fraction of Na-22 beta particles transmitted through the dead layer of skin (0.007 cm) is approximately 78%.
- Rule of Thumb:
  - 500 keV betas can penetrate approximately 4 feet in air
  - 500 kev betas can penetrate approximately 2 mm of water or tissue

Shielding

MATERIAL	THICKNESS
Lead Brick	(1" to 2" thick)

Half-Value Layer* [lead (11.34 g/cm^3)]	1.01 cm = 0.40" (1/4")
Half-Value Layer [concrete (2.35 g/cm^3)]	5.15 cm = 2.03"

Tenth-Value Layer** (lead)	3.4 cm = 1.34"
Tenth-Value Layer (concrete)	17.1 cm = 6.73"

* Half-Value Layer (HVL) = amount of shielding necessary to reduce a radiation exposure rate to 1/2 (50%) of its original value.
** Tenth-Value Layer (TVL) = amount of shielding necessary to reduce a radiation exposure rate to 1/10 (10%) of its original value.

Volatility

Inherent Volatility (STP): Insignificant/Negligible

Exposure: Radiological Safety Information

Exposure Rates

From an unshielded isotropic point source of Na-22 (1.0 mCi):

DISTANCE	MILLIREM/HOUR
1.00 cm	12,000
5.00 cm	480
10.00 cm	120
100.00 cm	1.2
6 inches	51.7

Exposure Prevention

- **Always** wear a lab coat and disposable gloves when handling Na-22.

Engineering Controls

- Drying can form airborne Na-22 dust contamination. Rapid boiling can cause airborne Na-22 contamination.
- Expelling Na-22 solutions through syringe needles and pipette tips can generate airborne aerosols.
- Use high-density (high Z) shielding material to shield Na-22 (lead).
- Use remote handling tools when handling > 1 mCi of Na-22.

Administrative Controls

- Sealed and plated sources of Na-22 (>100 uCi) MUST be leak-tested and inventoried by RSS personnel once every 6 months. Research personnel must maintain a current inventory of Na-22 sources at all times.

Personal Safety

- Na-22 sources MUST be secured from unauthorized use, removal, and vandalism at all times (secure in locked cabinet when not in use).

Regulatory Compliance Limits (10 CFR 20/Appendix B)

REGULATION	UNIT OF MEASURE	NOTES
Derived Air Concentration (DAC) (Occupational Exposures)	3.0E-7 uCi/mL (all compounds)	
Airborne Effluent Release Limit (Annual Average)	9.0E-10 uCi/mL (all compounds)	Applicable to the assessment and 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)	10 uCi	
Leak Tests (Sealed/Plated Sources > 100 uCi)	Semi-Annually	

Annual Limit on Intake (ALI)

- 400 uCi (all compounds/oral ingestion/CEDE/Whole Body/5 rem)
  - 1.0 ALI = 400 uCi ingested (all compounds) = 5,000 millirem CEDE/WB
- 600 uCi (all compounds/inhalation/CEDE/WB/5 rem/Class "D")
  - 1.0 ALI = 600 uCi inhaled (all compounds) = 5,000 millirem CEDE/WB

Contamination

Radiological Data

Na-22 is eliminated from the body via the urine with an 11-day half-life

Critical Organ (Biological Destination)	Total Body
Routes of Intake	• Ingestion • Inhalation • Puncture • Wound • Skin Contamination (absorption)
External and internal exposure and contamination are radiological concerns	Committed Dose Equivalent (CDE): (Internal Organs) • 20.5 mrem/uCi (ingestion/endosteal) (Internal Organs) • 15.9 mrem/uCi (ingestion/bone marrow) • 13.0 mrem/uCi (inhalation/endosteal) • 8.3 mrem/uCi (inhalation/bone marrow) Committed Effective Dose Equivalent (CEDE): • 12.5 mrem/uCi (ingestion/whole body)

Skin Contamination (Na-22)

- Skin Contamination Exposure Rate: 5,065 mrem/hour per uCi/cm^2
  - Dose to basal cells at depth of 7 mg/cm^2 or 0.007 cm in skin tissue without air reflection
- Skin Contamination Exposure Rate: 1,266 mrem/hour per uCi/cm^2
  - Dose to skin of extremities at a depth of 30-50 mg/cm^2 or 0.05 cm in tissue without air reflection

Detect Contamination

Survey Instrumentation

- Monitor personnel (hands, clothing, shoes, etc) work areas, and floors using a G-M survey meter equipped with a pancake/frisker probe (preferred) for gross contamination.
- Survey meter equipped with a G-M pancake/frisker or standard cylindrical G-M probes are quite efficient to detect Na-22.
- Survey meter equipped with a 1"x1" NaI scintillation probe will be very efficient for the detection of Na-22; perhaps, too sensitive and costly 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 Na-22 on smears or swabs.

Required Personal Radiation Monitoring

- Dosimeters (Whole Body and Finger Tabs): **Required** when handling > 5.0 mCi of Na-22 at **any** time.
- Urinalyses: Not Required; however, may be requested by RSS personnel after a radioactive spill of Na-22 or a suspected intake.
- Whole Body Bioassay: May be requested after suspected intake of Na-22.