Appendix A

Safe Handling Procedures
For Common Research Isotopes

This appendix is intended as a guide for the radioactive material workers at Creighton University and Creighton University Medical Center. It is not intended to provide anything more than guidance. The CU/CUMC Radiation Safety Committee may require and/or approve safety precautions which are not as described in this appendix. All questions should be directed to the Radiation Safety Office.

I. Hydrogen 3

A. Physical Data

Radiation: Beta particle
Maximum Energy: 19 keV
Intensity: 100%
Maximum Range in Air: 4.7 mm
Annual Limit on Intake: 80 mCi
Halflife: 12.28 years

B. Health Physics

Millicurie quantities present no external exposure hazard as the low energy betas can not penetrate the dead layer of skin. Many tritiated compounds penetrate gloves and skin; wearing two pairs of gloves and changing the outer pair at least every 20 minutes is advised. The critical organ for H-3 uptake is whole body (water). Tritiated water is uniformly distributed through the body in 3 to 4 hours. The biological halflife for tritiated water is about 10 days. Elimination rates can be increased by increasing water intake. Tritiated DNA precursors are considered more toxic but are generally less volatile and normally do not present a significantly greater hazard.

C. Dosimetry

Film, OSL, and TLD badges are not sensitive to H-3 so are not required. Bioassay by urinalysis is required for all individuals working with quantities exceeding the limits in Table 4.T1 in any three month period. Action level for H-3 is 5 nCi/ml of urine.

D. Instrumentation

To detect H-3, use an open window ionization detector or liquid scintillation counter (LSC) for all detections.

E. Waste Disposal

Tritium is considered a long-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.

II. Carbon-14

A. Physical Data

Radiation: Beta particle
Maximum Energy: 156 keV
Intensity: 100%
Maximum range in air: 22 cm
Annual Limit on Intake: 2 mCi
Halflife: 5730 years

B. Health Physics

Millicurie quantities of C-14 present no external exposure hazard as the low energy betas barely penetrate the dead layer of skin. C-14 labeled compound uptake may be assumed to be uniformly distributed throughout all organs and tissues in the body. Most are rapidly metabolized and is exhaled as $^{14}CO_2$. Some metabolites are eliminated via the urine. Biological halflives vary from a few minutes to 40 days, 10 days being a conservative value for most compounds.

C. Dosimetry:

Film, OSL and TLD badges are only slightly sensitive to the low energy betas. Therefore, they are not required for users working only with C-14.

D. Instrumentation:

To detect C-14, use open window ionization detectors or liquid scintillation counters (LSC) for accurate assays and contamination surveys. End window GM detectors, pancake detectors, et.al., can detect C-14 with limited efficiency.

E. Waste Disposal

Carbon-14 is considered a long-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.

III. Phosphorus-32

A. Physical Data

Radiation: Beta particle
Maximum energy: 1.71 MeV
Intensity: 100%
Maximum range in air: 600 cm
Annual Limit on Intake: 600 uCi for oral ingestion;
400 uCi for inhalation
Halflife: 14.27 days

B. Health Physics

P-32 presents an external radiation hazard and an internal radiation hazard. The P-32 external hazard arises from the high energy beta at close ranges, and can present a substantial skin and eye dose hazard. The dose rate at the mouth of an open Perkin Elmer combi-vial containing 1 millicurie of P-32 is about 26,000 mR/hr. Lucite or other plastic shielding (1/2 inch or more) should be used to shield P-32. These low-Z materials absorb the beta particles while generating little secondary radiation. Thin layers of lead (.125 to .250 inch) may be used outside of the Lucite if necessary to further shield the radiation emitted. DO NOT SHIELD P-32 WITH LEAD BEFORE THE LUCITE. The bremstrahllung radiation will be increased dramatically if the lead is used to shield P-32 before the lucite.

Should gloves or clothes become contaminated, change them immediately to avoid high skin dose. Uptakes of P-32 are assumed to be retained with a biological halflife of 0.5 days. Of this, 15% is rapidly excreted, 15% is retained in intracellular fluids with a biological halflife of 2 days; 40% is retained in soft tissue with a biological halflife of 19 days; and 30% is retained permanently in the bone.

C. Dosimetry:

Film, OSL, and TLD badges are all sensitive to P-32. All users of P-32 shall be issued one of these whole body badges. Users who put into process 1 millicurie or more at a time on a frequent (i.e., monthly) basis may be issued ring badges at the discretion of the Radiation Safety Officer.

D. Instrumentation:

To detect P-32, use an open window ionization detector or liquid scintillation counter (LSC) for accurate assays and contamination surveys. End window GM detectors, pancake detectors, et. al., detect P-32 with good efficiency. NaI thin window scintillation probes can detect P-32 with reasonable efficiency.

E. Waste Disposal

Phosphorus-31 is considered a short-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.

IV. Sulfur-35

A. Physical Data

Radiation: Beta particle
Maximum energy: 167 keV
Intensity: 100%
Maximum range in air: 24 cm
Annual Limit on Intake: 6 mCi for oral ingestion
2 mCi for inhalation
Halflife: 88 days

B. Health Physics

Millicurie quantities of S-35 do not present a significant exposure hazard since the low energy beta particles barely penetrate the dead layer of skin. Some S-35 compounds, including Methionine, generate volatile fractions particularly during lyophilization or incubation. The critical organ for S-35 is the whole body, uptakes are assumed to be uniformly distributed throughout all organs and tissues. The metabolism and retention rate of S-35 depends on the chemical form. Most S-35 labeled compounds are eliminated via the urine. 90 days is a conservative estimate of the biological halflife.

C. Dosimetry:

Film, OSL, and TLD badges are only slightly sensitive to S-35 and are not required. However, users who put into process 1 millicurie or more at a time on a frequent (i.e., monthly) basis may be issued dosimetry at the discretion of the Radiation Safety Officer.

D. Instrumentation:

To detect S-35, use an open window ionization detector or liquid scintillation counter (LSC) for accurate assays and contamination surveys. End window GM detectors, pancake detectors, et. al., detect S-35 with limited efficiency.

E. Waste Disposal

Sulfur-35 is considered a short-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.

V. Calcium-45

A. Physical Data

Radiation: Beta particle
Maximum energy: 247 keV
Intensity: 100%
Maximum range in air: 48 cm
Annual Limit on Intake: 2 mCi for oral ingestion
800 uCi for inhalation
Halflife: 163 days

B. Health Physics

Millicurie quantities of Ca-45 do not present a significant exposure hazard since the low energy beta particles barely penetrate gloves and the outer dead layer of skin. The critical organ for Ca-45 is the bone. The metabolism of Ca-45 is complex. The majority of Ca-45 is deposited in the bone and is retained with a long biological halflife of 1.8e4 days. A smaller fraction is rapidly eliminated. Ca-45 is initially eliminated via the urine but eventually half of the radionuclide is eliminated via the feces.

C. Dosimetry:

Film, OSL, and TLD badges are only slightly sensitive to Ca-45 and are not required. However, users who put into process 1 millicurie or more at a time on a frequent (i.e., monthly) basis may be issued dosimetry at the discretion of the Radiation Safety Officer. Bioassay by urinalysis is required for individuals working with quantities of 100 millicuries or more in any 3 month period. The action level for Ca-45 is 5 nCi/ml of urine.

D. Instrumentation:

To detect Ca-45, use an end-window Geiger Muller detector or liquid scintillation counter (LSC) for accurate assays and contamination surveys. Most G.M. detectors, pancake probes and NaI probes can detect Ca-45 with some efficiency.

E. Waste Disposal

Calcium-45 is considered a short-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.

VI. Iodine-125

A. Physical Data

Radiation: Gamma Ray
Maximum energy: 35 keV, 27 keV, 31 keV
Intensity: 6.5%, 112.5% and 25.4% respectively
Annual Limit on Intake: 40 uCi for oral ingestion
60 uCi for inhalation
Halflife: 59.9 days

B. Health Physics

The thyroid is the critical organ for I-125 uptake. The thyroid can be assumed to accumulate 30% of the soluble iodine uptake and retain iodine with a 120 day biological halflife. The remainder of the Iodine can be assumed to leave the body primarily via the urine and slightly through perspiration and saliva with a biological halflife of 12 days. Sodium iodine solutions should be stored at room temperatures to avoid volatilization through sublimation. Iodine can penetrate most gloves and is highly percutaneous. Use remote tools to handle iodine when possible and wear two pairs of gloves, changing the outer pair frequently. Unbound iodine is highly volatile, handle 10 uCi or greater quantities of unbound iodine in a fume hood.

C. Dosimetry:

Film, OSL, or TLD badges are to be worn by anyone working with 100 uCi or greater quantities of I-125. Bioassays are required for individuals working with I-125 in quantities exceeding those listed in table 4.T1.

D. Instrumentation:

Iodine-125 can be best detected using a sodium iodide detector (NaI) scintillation detector. Assaying can best be done using either a gamma well counter or a liquid scintillation counter.

E. Waste Disposal

Iodine-125 is considered a short-lived isotope and waste should be handled according to Section 13 of the Radiation Safety Manual.