^{57}Co	Nuclide Safety Data Sheet Cobalt - 57 **www.nchps.org**	^{57}Co

I. PHYSICAL DATA

Radiation[1]:	Gamma & X-ray: 6-7 keV (56% abundance), 122 keV (85%), 136 keV (11%)
	Electrons: 0.7 keV (249% abundance), 6-7 keV (175%), 14 keV (9%)
Gamma Constant:	4.09E-5 mSv/hr per MBq at 1 m (0.151 mrem/hr per mCi @ 1m)[1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 270.9 days[1]
	Biological $T_{½}$: ~ 1.5 days[2]
	Effective $T_{½}$: ~ 1.5 days
Specific Activity[3]:	8.43E3 Ci/g [3.12E14 Bq/g]

II. RADIOLOGICAL DATA

Radiotoxicity:	1.18 mrem/uCi [3.2E-10 Sv/Bq] of ^{57}Co ingested [CEDE][4]
	9.1 mrem/uCi [2.45E-9 Sv/Bq] of ^{57}Co inhaled [CEDE][4]
Critical Organ:	Lung (inhalation)[3,4]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination/absorption
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer (HVL)	Tenth Value Layer (TVL)
Lead [Pb][3]	6 mm	18 mm

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{57}Co
- Submit a urine sample to Radiation Safety two to 24 hours [i.e. As Soon As Possible] after any suspected intake of ^{57}Co.

V. DETECTION & MEASUREMENT

Portable Survey Meters	Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
	Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys
Wipe Test:	Gamma Counter, Well Gamma Counter, or Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store ^{57}Co behind adequate lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{57}Co is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and <2 mR/hr

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[1] Shleien et al, Handbook of Health Physics and Radiological Health (Baltimore, MD: Williams & Wilkins, 1998), p. 6-9 & 8-52

[2] BNL/NRC, Interpretation of Bioassay Measurements [NUREG/CR-4884] (Nuclear Regulatory Commission, 1987), p.B-375 & B -523

[3] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook 2002 (Kent, England: Nuclear Technology Publishing, 2002), p. 55

[4] Federal Guidance Report No. 11 (Oak Ridge, TN; Oak Ridge National Laboratory, 1988), p. 125, 157

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{51}Cr	Nuclide Safety Data Sheet Chromium-51 **www.nchps.org**	^{51}Cr

I. PHYSICAL DATA

Radiation:	Gamma - 320 keV (9.8% abundance)
	X-ray - 5 keV (22% abundance)
Gamma Constant:	0.023 mR/hr per mCi @ 1.0 meter [6.32E-6 mSv/hr per MBq @ 1.0 meter][1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 27.7 days
	Biological 616 days
	Effective $T_{½}$: 26.6 days (whole body)
Specific Activity:	9.24E4 Ci/g [3.42E3 TBq/g] max.

II. RADIOLOGICAL DATA

Radiotoxicity:	0.145 mrem/uCi of ^{51}Cr ingested [CEDE]
	0.334 mrem/uCi of ^{51}Cr inhaled [CEDE]
Critical Organ:	Lower Large Intestine [LLI]
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	2 mm (0.07 inches)	6.6 mm (0.23 inches)
Concrete	2.8 cm (1.1 inches)	9.3 cm (3.7 inches)
Plexiglas	4.8 cm (1.9 inches)	16 cm (6.3 inches)

The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{51}Cr

V. DETECTION & MEASUREMENT

Portable Survey Meters	Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
	Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys
Wipe Test:	Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store ^{51}Cr (including waste) behind lead shielding [¼ - ½ inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background)
- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding to minimize exposure while handling ^{51}Cr
- Use tools to handle ^{51}Cr sources and contaminated objects; avoid direct hand contact

[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-9

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{18}F	Nuclide Safety Data Sheet Fluorine – 18 **www.nchps.org**	^{18}F

I. PHYSICAL DATA

Radiation:	Gamma: 511 keV (194% abundance; positron annihilation radiation)	
	Betas: 634 keV (97% abundance) [Positron]	
Gamma Constant:	1.879E-04 mSv/hr per MBq at 1 meter[1] [6.952E-4 mrem/hr per uCi at 1 m]	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	1.83 hours[2]
	Biological $T_{½}$:	~ 6 hours[3]
	Effective $T_{½}$:	~ 1.4 hours
Specific Activity:	9.51E7 Ci/g [3.52E18 Bq/g] [2]	

II. RADIOLOGICAL DATA

Radiotoxicity[4]:	Ingested:	2.9E-10 Sv/Bq [1.1 mrem/uCi] stomach wall
		3.31E-11 Sv/Bq [0.12 mrem/uCi] CEDE
	Inhaled:	1.4E-10 Sv/Bq [0.52 mrem/uCi] Lung
		2.3E-11 Sv/Bq [0.084 mrem/uCi] CEDE
Critical Organ[4]:	Lung (inhalation); stomach wall (ingestion)	
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption	
Radiological Hazard:	External & Internal Exposure; Contamination	

III. SHIELDING[2]

	Gamma:	Half Value Layer (HVL)	Tenth Value Layer (TVL)
Lead [Pb]		6 mm	17 mm

Beta Shielding: 1.7 mm plastic

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{18}F

V. DETECTION & MEASUREMENT

Portable Survey Meters	Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
Wipe Test:	Gamma Counter, Gamma Well Counter, or Liquid Scintillation Counter (wipes must be run soon after sample collection due to short half-life)

VI. SPECIAL PRECAUTIONS

- Store ^{18}F behind lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{18}F is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr
- ^{18}F's short half life (109.8 minutes) makes rigorous inventory tracking unnecessary. Also, storage for decay can normally be accomplished at the point of use, since ^{18}F compounds will decay to background levels within a day or two.

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[1] Shleien et al, Eds. Handbook of Health Phys. & Rad. Health, 3rd ed. (Baltimore, MD: Williams & Wilkins, 1998), p. 6-9

[2] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 24

[3] Saha, G. Fundamentals of Nuclear Pharmacy, 2nd ed. (New York: Springer-Verlag, 1984), p. 238

[4] Federal Guidance Report No. 11 (Oak Ridge, TN; Oak Ridge National Laboratory, 1988), p. 156, 122

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{67}Ga	Nuclide Safety Data Sheet Gallium-67 **www.nchps.org**	^{67}Ga

I. PHYSICAL DATA

Radiation:	Gammas/X-rays: 8.6 keV (~49% abundance); 9.3 keV (~36%); 184 keV (~20%); 300 keV (~16%); others (1 – 889 keV, all < 10%)[1] Electrons: 1 keV (~165% abundance); 7.5 keV (~60%); 84 keV (~27%); others (< 175 keV, < 5%)[1]
Gamma Constant:	1.04 mR/hr per mCi @ 1.0 meter [2.8E-4 mSv/hr per MBq @ 1.0 meter]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 3.26 days[1] Biological $T_{½}$: ~12 years [gallium citrate]; varies Effective $T_{½}$: ~3.3 days [varies]
Specific Activity:	5.97E4 Ci/g [2,210 TBq/g] max[2]

II. RADIOLOGICAL DATA

Radiotoxicity[3]:	2.12E-10 Sv/Bq (0.78 mrem/uCi) of ^{67}Ga ingested [CEDE] 1.51E-10 Sv/Bq (0.56 mrem/uCi) of ^{67}Ga inhaled [CEDE]
Critical Organ:	Lower large intestine[2]
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	Internal Exposure; Contamination

III. SHIELDING[2]

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	1 mm (0.04 inches) Electrons [total absorption]	6 mm (0.12 inches)
Plexiglas	0.2 mm (0.08 inches)	

The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{67}Ga
Virtually no urinary excretion; elimination primarily via fecal excretion

V. DETECTION & MEASUREMENT

Portable Survey Meters	Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
	Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys
Wipe Test:	Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]

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[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 8-53
[2] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 57
[3] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 125, 158

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional waste handling & disposal procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{111}In	Nuclide Safety Data Sheet Indium-111 **www.nchps.org**	^{111}In

I. PHYSICAL DATA

Primary Radiation:	Gamma – 245 keV (94% abundance), 171 keV (90% abundance), 23 keV (69% abundance)
Gamma Constant:	3.7 mrem/hr at 30 cm from 1 mCi [9.9E-4 mSv/hr at 30 cm from 1 MBq][1]
Physical Half-Life [$T_{½}$] :	2.80 days
Specific Activity:	4.19E5 Ci/g [1.55E16 Bq/g][1]

II. RADIOLOGICAL DATA

Radiotoxicity:	1,330 mrem/mCi [3.59E-7 mSv/Bq] of ^{111}In ingested [CEDE][3] 840 mrem/mCi [2.27E-7 mSv/Bq] of ^{111}In inhaled [CEDE] [2]
Critical Organ:	Lower Large Intestine[1]
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	Internal and External Exposure, Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	<1 mm	3 mm

→ The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{111}In

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. Bicron PGM,] to assess shielding effectiveness

Low Energy Gamma Detector for contamination surveys

VI. SPECIAL PRECAUTIONS

- Store ^{111}In behind ¼-inch [~ 0.6 cm] thick lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{111}In is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr

[1] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 78

[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 133, 163

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions], such as: use the materials only within an approved fume hood; protect the house vacuum system with primary & secondary vapor trapping devices; and cover active cell cultures with carbon-impregnated paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.

^{123}I	Nuclide Safety Data Sheet Iodine-123 **www.nchps.org**	^{123}I

I. PHYSICAL DATA

Radiation:	Electrons – 3 keV (94%); 23 keV (12%); 127 keV (14%); others (<2%)
	Gamma & X-ray – 159 keV (83%); 27 keV (70%); 31 keV (16%); others (< 10%)
Gamma Constant:	0.277 mrem/hr per mCi @ 1.0 meter [7.478 E-5 mSv/hr per MBq @ 1.0 meter][a]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 13.13 hours[a]
	Biological $T_{½}$: 120-138 days (unbound iodine)
	Effective $T_{½}$: ~ 12 hours (unbound iodine)
Specific Activity:	1.93E6 Ci/g [7.14E16 Bq/g] max.[b]

II. RADIOLOGICAL DATA

Radiotoxicity[c]:	4.42 E-9 Sv/Bq (16 mrem/uCi) of ^{123}I ingested [Thyroid]
	2.25 E-9 Sv/Bq (8.3 mrem/uCi) of ^{123}I inhaled [Thyroid]
Critical Organ:	Thyroid Gland
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb][b]	1 mm (0.04 inches)	2 mm (0.08 inches)

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{123}I
- Conduct a baseline thyroid scan prior to first use of radioactive iodine
- Conduct thyroid bioassay measurement [at neck just above collar bone] no earlier than 6 hours but within 72 hours of handling 1 mCi (37 MBq) or more of ^{123}I or after any suspected intake

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness

Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys

Wipe Test: Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{123}I
- Avoid making low pH [acidic] solutions containing ^{123}I to avoid volatilization
- For Iodinations:
  - Use a cannula adapter needle to vent stock vials of ^{123}I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other tight caps to prevent release while counting or moving outside the fume hood.

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[a] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-11

[b] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 87

[c] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 136, 166

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{125}I	Nuclide Safety Data Sheet Iodine-125 **www.nchps.org**	^{125}I

I. PHYSICAL DATA

Radiation:	Gamma - 35.5 keV (7% abundance)
	X-ray - 27 keV (113% abundance)
Gamma Constant:	0.27 mR/hr per mCi @ 1.0 meter [7.432E-5 mSv/hr per MBq @ 1.0 meter][1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 60.14 days
	Biological $T_{½}$: 120-138 days (unbound iodine)
	Effective $T_{½}$: 42 days (unbound iodine)
Specific Activity:	1.73E4 Ci/g [642 TBq/g] max.

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	3.44E-7 Sv/Bq (1273 mrem/μCi) of ^{125}I ingested [Thyroid]
	2.16 E-7 Sv/Bq (799 mrem/μCi) of ^{125}I inhaled [Thyroid]
Critical Organ:	Thyroid Gland
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	0.02 mm (0.0008 inches)	0.07 mm (0.003 inches)

→ The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{125}I
- Conduct a baseline thyroid scan prior to first use of radioactive iodine
- Conduct thyroid scan no earlier than 6 hours but within 72 hours of handling 1 mCi or more of ^{125}I or after any suspected intake

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. Bicron PGM,] to assess shielding effectiveness

Low Energy Gamma Detector [e.g. Ludlum 44-21, ~19% eff. for ^{125}I] for contamination surveys

Wipe Test: Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{125}I
- Avoid making low pH [acidic] solutions containing ^{125}I to avoid volatilization
- For Iodinations:
  - Use a cannula adapter needle to vent stock vials of ^{125}I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other tight caps to prevent release while counting or moving outside the fume hood.

[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-11

[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 136, 166

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following DU/DUMC Waste Handling & Disposal Procedures - http://www.safety.duke.edu/EnviroPrograms/Radiopro.htm. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety at 684-2194.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{131}I	Nuclide Safety Data Sheet Iodine-131 **www.nchps.org**	^{131}I

I. PHYSICAL DATA

Radiation:	Gammas & X-rays: primary 364 keV (81% abundance); others – 723 keV
	Betas: primary 606 keV (89% abundance); others 248 – 807 keV
Gamma Constant:	0.28 mR/hr per mCi @ 1.0 meter [7.647E-5 mSv/hr per MBq @ 1.0 meter][1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 8.04 days
	Biological $T_{½}$: 120-138 days (unbound iodine)
	Effective $T_{½}$: 7.6 days (unbound iodine)
Specific Activity:	1.24E5 Ci/g [4,600 TBq/g] max.

II. RADIOLOGICAL DATA

Radiotoxicity[2]:	4.76 E-7 Sv/Bq (1.76 rem/uCi) of ^{131}I ingested [Thyroid]
	2.92 E-7 Sv/Bq (1.08 rem/uCi) of ^{131}I inhaled [Thyroid]
Critical Organ:	Thyroid Gland
Intake Routes:	Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb][3]	3 mm (0.12 inches)	11 mm (0.43 inches)

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{131}I
- Conduct a baseline thyroid scan prior to first use of radioactive iodine
- Conduct thyroid bioassay measurement [at neck just above collar bone] no earlier than 6 hours but within 72 hours of handling 1 mCi or more of ^{131}I or after any suspected intake

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. PGM] to assess shielding effectiveness & contamination

Wipe Test: Liquid Scintillation Counter or Gamma Counter

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{131}I
- Avoid making low pH [acidic] solutions containing ^{131}I to avoid volatilization
- For Iodinations:
  - Use a cannula adapter needle to vent stock vials of ^{131}I used; this prevents puff releases
  - Cover test tubes used to count or separate fractions from iodinations with parafilm or other tight caps to prevent release while counting or moving outside the fume hood.

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[1] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-11
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 136, 166
[3] HVL & TVL values from: Delacroix, D. et al. Radionuclide and Radiation Protection Handbook [*Radiation Protection Dosimetry*, vol.76, nos 1-2, 1998, Nuclear Technology Publishing, Ashford, Kent, England, 1998], p. 90

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional waste handling & disposal procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{32}P	Nuclide Safety Data Sheet Phosphorous-32 **www.nchps.org**	^{32}P

I. PHYSICAL DATA

Radiation:	Beta (100% abundance)	
Energy:	Maximum: 1,710 keV; Average: 695 keV	
Half-Life [$T_{½}$] :	Physical $T_{½}$:	14.29 days
	Biological $T_{½}$:	Bone ~ 1155 days; Whole Body ~ 257 days[1]
	Effective $T_{½}$:	14.29 days
Specific Activity:	286,500 Ci/g [10,600 TBq/g] max.	
Beta Range:	Air:	610 cm [240 inches; 20 feet]
	Water/Tissue:	0.76 cm [0.33 inches]
	Plastic:	0.61 mm [3/8 inches]

II. RADIOLOGICAL DATA

Radiotoxicity[2]: Inhaled: 2.6E-8 Sv/Bq [95 mrem/uCi] Lung; 4.2E-9 Sv/Bq [16 mrem/uCi] CEDE
Ingested: 8.1E-9 Sv/Bq [30 mrem/uCi] Marrow; 2.4E-9 Sv/Bq [8.8 mrem/uCi] CEDE
Critical Organ: Bone [soluble ^{32}P]; Lung [Inhalation]; GI Tract [Ingestion - insoluble compounds]
Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard: External Exposure [unshielded dose rate at 1 mCi ^{32}P vial mouth[3]: approx. 26 rem/hr], Internal Exposure & Contamination

III. SHIELDING

Shield ^{32}P with 3/8 inch Plexiglas and monitor for Bremstrahlung; If Bremstrahlung X-rays detected outside Plexiglas, apply 1/8 to 1/4 inch lead [Pb] shielding outside Plexiglas
The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{32}P

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM];
Beta Scintillator [e.g. Ludlum 44-21]
Wipe Test: Liquid Scintillation Counting is an acceptable method for counting ^{32}P wipe tests

VI. SPECIAL PRECAUTIONS

- Avoid skin contamination [absorption], ingestion, inhalation, & injection [all routes of intake].
- Store ^{32}P (including waste) behind Plexiglas shielding [3/8 inch thick]; survey (with GM meter) to check adequacy of shielding (accessible dose rate < 2 mR/hr; should be background); apply lead [Pb] shielding outside Plexiglas if needed.
- Use 3/8 inch Plexiglas shielding to minimize exposure while handling ^{32}P.
- Use tools [e.g. Beta Blocks] to handle ^{32}P sources and contaminated objects; avoid direct hand contact.
- Always have a portable survey meter present and turned on when handling ^{32}P.
- ^{32}P is not volatile, even when heated, and can be ignored as an airborne contaminant[4] unless aerosolized.
- White vinegar can be an effective decontamination solvent for this nuclide in most forms.

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[1] NCRP Report No. 65, p.88
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 122, 156
[3] Dupont/NEN, Phosphorous-32 Handling Precautions [Boston, MA; NEN Products, 1985]
[4] Bevelacqua, J. Contemporary Health Physics [New York; John Wiley & Sons, 1995], p. 282

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note lab staff are not permitted to pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{90}Sr	Nuclide Safety Data Sheet Strontium-90 **www.nchps.org**	^{90}Sr

I. PHYSICAL DATA

Primary Radiation[1]: Beta – 546 keV (100%); ^{90}Y Betas – 2,484 keV (~100%), 523 keV (<1%)
Skin Dose Rate[1]: 7.3E2 mrem/hr at 30 cm from 1 uCi [0.20 mSv/hr at 30 cm from 1 MBq]
Physical Half-Life[1] [$T_{½}$] 28.2 years

Specific Activity[1]: 1.41E2 Ci/g [5.21E12 Bq/g]

II. RADIOLOGICAL DATA

Radiotoxicity[2]: Ingested: 1.6E3 mrem/uCi [4.19E-7 Sv/Bq] Bone
1.4E2 mrem/uCi [3.85E-8 mSv/Bq] CEDE
Inhaled: 1.1E4 mrem/uCi [2.86E-6 mSv/Bq] Lung
1.3E3 mrem/uCi [3.51E-7 mSv/Bq] CEDE
Critical Organ: Bone [ingestion][2]; Lungs [inhalation][1]
Intake Routes: Ingestion, inhalation, puncture, wound, skin contamination (absorption);
Radiological Hazard: Internal and External Exposure, Contamination

III. SHIELDING

Plexiglas[1] 9.2 mm
→ The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{90}Sr

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness & locate contamination
Wipe Test: Gamma counter, well counter or liquid scintillation counter

VI. SPECIAL PRECAUTIONS

- Store ^{90}Sr behind 12 mm [1/2 inch] or thicker plastic (e.g. Plexiglas) shielding as necessary to keep accessible dose rate low [< 2 mR/hr]
- Use tools (e.g. tongs, forceps; plastic blocks) to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{90}Sr is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr

[1] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 2002), p. 80
[2] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 128, 160

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions], such as: use the materials only within an approved fume hood; protect the house vacuum system with primary & secondary vapor trapping devices; and cover active cell cultures with carbon-impregnated paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms. Notify Radiation Safety staff before taking any radioactive material off site.

^{99m}Tc	Nuclide Safety Data Sheet Technetium - 99m **www.nchps.org**	^{99m}Tc

I. PHYSICAL DATA

Radiation:	Gamma: 141 keV (89% abundance)
	X-rays: 18 keV (6% abundance), 21 keV (1.2% abundance)
Gamma Constant:	0.77 R/hr at 1 cm from an unshielded 1 mCi point source[1]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 6.0 hours
	Biological $T_{½}$: ~ 1 day[2]
	Effective $T_{½}$: ~ 4.8 hours
Specific Activity:	5.27E6 Ci/g [1.95E17 Bq/g]

II. RADIOLOGICAL DATA

Radiotoxicity:	0.062 mrem/mCi [1.68E-11 Sv/Bq] of ^{99m}Tc ingested [CEDE][3]
	0.27 mrem/mCi [7.21E-11 Sv/Bq] of ^{99m}Tc inhaled [CEDE][3]
Critical Organ:	Thyroid Gland[3]; Upper GI tract[1]
Exposure Routes:	Ingestion, inhalation, puncture, wound, skin contamination absorption
Radiological Hazard:	External & Internal Exposure; Contamination

III. SHIELDING

	Half Value Layer (HVL)	Tenth Value Layer (TVL)
Lead [Pb]	<1 mm	1 mm

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{99m}Tc
- Submit a urine sample to Radiation Safety two to 24 hours [i.e. As Soon As Possible] after any suspected intake of ^{99m}Tc; alert Radiation Safety of the short half-lived nuclide involved.

V. DETECTION & MEASUREMENT

Portable Survey Meters	Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness
	Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys
Wipe Test:	Gamma Counter, Well Gamma Counter, or Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store ^{99m}Tc behind ¼-inch [~ 0.6 cm] thick lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{99m}Tc is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr

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[1] Dupont/NEN, Technetium-99m Handling Precautions (Boston, MA: NEN, 1985)

[2] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 71

[3] Federal Guidance Report No. 11 (Oak Ridge, TN; Oak Ridge National Laboratory, 1988), p. 130, 162

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{201}Tl	Nuclide Safety Data Sheet Thallium – 201 **www.nchps.org**	^{201}Tl

I. PHYSICAL DATA

Radiation: Gamma: 71 keV (47%); 135 keV (3%); 167 keV (10%)

Gamma Constant: 2.372E-5 mSv/hr per MBq at 1 meter[1] [8.78E-5 mrem/hr per uCi at 1 m]

Half-Life [$T_{½}$] : Physical $T_{½}$: 3.04 days[2]
Biological $T_{½}$: ~ 10 days[3]
Effective $T_{½}$: ~ 2.3 days

Specific Activity: 2.14E5 Ci/g [7.90E15 Bq/g] [2]

II. RADIOLOGICAL DATA

Radiotoxicity[4]: Ingested: 1.2E-10 Sv/Bq [0.44 mrem/uCi] stomach wall
8.1E-11 Sv/Bq [0.30 mrem/uCi] CEDE
Inhaled: 1.7E-10 Sv/Bq [0.63 mrem/uCi] Lung
6.3E-11 Sv/Bq [0.23 mrem/uCi] CEDE

Critical Organ[4]: Lung (inhalation); stomach wall (ingestion)

Exposure Routes: Ingestion, inhalation, puncture, wound, skin contamination absorption

Radiological Hazard: External & Internal Exposure; Contamination

III. SHIELDING[2]

Gamma:	Half Value Layer (HVL)	Tenth Value Layer (TVL)
Lead [Pb]	<1 mm	1 mm

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{201}Tl

V. DETECTION & MEASUREMENT

Portable Survey Meters: Geiger-Mueller [e.g. Bicron PGM] to assess shielding effectiveness

Wipe Test: Gamma Counter, Well Gamma Counter, or Liquid Scintillation Counter

VI. SPECIAL PRECAUTIONS

- Store ^{201}Tl behind lead (Pb) shielding
- Use tools to indirectly handle unshielded sources and potentially contaminated vessels; avoid direct hand contact
- Ensure that an appropriate, operational survey meter (e.g. Bicron PGM) is present in the work area and turned on whenever ^{201}Tl is handled, so that any external exposure issues will be immediately apparent and hence quickly addressed
- Shield waste containers as needed to maintain accessible dose rate ALARA and < 2 mR/hr
- ^{201}Tl's short half life (73.1 hours) makes rigorous inventory tracking unnecessary. Also, storage for decay can often be accomplished at the point of use, since ^{201}Tl compounds will decay to background levels within a month or two.

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[1] Shleien et al, Eds. Handbook of Health Phys. & Rad. Health, 3rd ed. (Baltimore, MD: Williams & Wilkins, 1998), p. 6-13

[2] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 116

[3] Saha, G. Fundamentals of Nuclear Pharmacy, 2nd ed. (New York: Springer-Verlag, 1984), p. 246

[4] Federal Guidance Report No. 11 (Oak Ridge, TN; Oak Ridge National Laboratory, 1988), p. 174, 148

VII. GENERAL PRECAUTIONS

1. Maintain your occupational exposure to radiation As Low As Reasonably Achievable [ALARA].
2. Ensure all persons handling radioactive material are trained, registered, & listed on an approved protocol.
3. Review the nuclide characteristics on (reverse side) prior to working with that nuclide. Review the protocol(s) authorizing the procedure to be performed and follow any additional precautions in the protocol. Contact the responsible Principal Investigator to view the protocol information.
4. Plan experiments to minimize external exposure by reducing exposure time, using shielding and increasing your distance from the radiation source. Reduce internal and external radiation dose by monitoring the worker and the work area after each use of radioactive material, then promptly cleaning up any contamination discovered. Use the smallest amount of radioisotope possible so as to minimize radiation dose and radioactive waste.
5. Keep an accurate inventory of radioactive material, including records of all receipts, transfers & disposal. Perform and record regular lab surveys.
6. Provide for safe disposal of radioactive waste by following institutional Waste Handling & Disposal Procedures. Avoid generating mixed waste (combinations of radioactive, biological, and chemical waste). Note that lab staff may not pour measurable quantities of radioactive material down the drain.
7. If there is a question regarding any aspect of the radiation safety program or radioactive material use, contact Radiation Safety.

VIII. LAB PRACTICES

1. Disposable gloves, lab coats, and safety glasses are the minimum PPE [Personal Protective Equipment] required when handling radioactive material. Remove & discard potentially contaminated PPE prior to leaving the area where radioactive material is used.
2. Clearly outline radioactive material use areas with tape bearing the legend "radioactive". Cover lab bench tops where radioactive material will be handled with plastic-backed absorbent paper; change this covering periodically and whenever it's contaminated. Alternatively cover benches with thick plastic sheeting (i.e., painter's drop cloth), periodically wipe it clean and replace it if torn.
3. Label each unattended radioactive material container with the radioactive symbol, isotope, activity, and, except for waste, the ICN [inventory control number]. Place containers too small for such labels in larger labeled containers.
4. Handle radioactive solutions in trays large enough to contain the material in the event of a spill.
5. Never eat, drink, smoke, handle contact lenses, apply cosmetics, or take/apply medicine in the lab; keep food, drinks, cosmetics, etc. out of the lab entirely. Do not pipette by mouth.
6. Never store [human] food and beverage in refrigerators/freezers used for storing radioisotopes.
7. Prevent skin contact with skin-absorbable solvents containing radioactive material.
8. Fume hoods and biological safety cabinets for use with non-airborne radioactive material must be approved (through the protocol) and must be labeled "Caution Radioactive Material".
9. All volatile, gaseous, or aerosolized radioactive material must be used only in a properly operating charcoal and/or HEPA filtered fume hood or Biological Safety Cabinet bearing a Caution Airborne Radioactivity hood label, unless otherwise specified in writing by the Radiation Safety Officer. In particular, radioactive iodination must be performed only in these specially designed fume hoods. The Radiation Safety Officer (through a protocol) must approve all such use.
10. Take special precautions when working with radioactive compounds that tend to become volatile [e.g. ^{35}S labeled amino acids, ^{125}I - iodine tends to volatilize in acidic solutions]. These precautions may include: using the materials only within an approved fume hood, protecting the house vacuum system with primary and secondary vapor trapping devices, and covering active cell cultures with carbon-impregnating paper.
11. Use sealed containers and appropriate secondary containment to carry radioactive material between rooms Notify Radiation Safety staff before taking any radioactive material off site.

^{133}Xe	Nuclide Safety Data Sheet Xenon-133 **www.nchps.org**	^{133}Xe

I. PHYSICAL DATA

Radiation[1]:	Gamma/X - 81 keV (38% abundance); 35 keV (7%); 31 keV (38%)
	Beta 346 keV max; 101 keV average (99% abundance)
Gamma Constant:	0.103 mR/hr per mCi @ 1.0 meter [2.78E-5 mSv/hr per MBq @ 1.0 meter][2]
Half-Life [$T_{½}$] :	Physical $T_{½}$: 5.25 days
	Biological $T_{½}$: Rapid (~minutes); small fraction deposited in fatty tissue
	Effective $T_{½}$: Rapid (~minutes)
Specific Activity[1]:	1.89E5 Ci/g [6.98E3 TBq/g] max.

II. RADIOLOGICAL DATA

Radiotoxicity[3]:	Submersion: 6.1E-12 Sv/hr per Bq/m³ [EDE]; 1.2E-11 Sv/hr per Bq/m³ [Bone]
Critical Organs:	Lung; bone; fatty tissue
Intake Routes:	Inhalation
Radiological Hazard:	External & Internal Exposure

III. SHIELDING

	Half Value Layer [HVL]	Tenth Value Layer [TVL]
Lead [Pb]	0.04 mm (0.002 inches)	0.37 mm (0.015 inches)

- The accessible dose rate should be background but must be < 2 mR/hr

IV. DOSIMETRY MONITORING

- Always wear radiation dosimetry monitoring badges [body & ring] whenever handling ^{133}Xe

V. DETECTION & MEASUREMENT

Portable Survey Meters:

Geiger-Mueller [e.g. Bicron PGM,] to assess shielding effectiveness

Low Energy Gamma Detector [e.g. Ludlum 44-21] for contamination surveys

Wipe Test: N/A – inert gas

VI. SPECIAL PRECAUTIONS

- Avoid inhalation [only significant route of intake]
- Use shielding [lead or leaded Plexiglas] to minimize exposure while handling mCi quantities of ^{133}Xe
- Ensure ^{133}Xe gas delivery systems are leak proof
- ^{133}Xe adheres to some plastics, rubber, greases & oils; handle in glass where possible

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[1] Delacroix et al, Radiation Protection Dosimetry - Radionuclide and Radiation Protection Data Handbook (Kent, England: Nuclear Technology Publishing, 1998), p. 91

[2] Health Physics & Radiological Health Handbook, 3rd Ed. [Baltimore, MD; Williams & Wilkins, 1998], p. 6-11

[3] Federal Guidance Report No. 11 [Oak Ridge, TN; Oak Ridge National Laboratory, 1988], p. 182

VII. GENERAL PRECAUTIONS

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