STATE UNIVERSITY OF NEW YORK
NEW PALTZ
SCHOOL OF SCIENCE AND ENGINEERING

SUNY – New Paltz Radiation Safety Manual

The SUNY – New Paltz Radiation Safety Manual contains the current official radiation safety procedures for SUNY – New Paltz and serves as the guidance document for the institution's radiation protection program. The purpose of this manual is to provide information and establish general procedures on the proper use and handling of [radioactive materials] radiation sources. It has been written with a view to afford the user as much freedom in his/her work as is safe and legal. The Radiation Safety Officer should be consulted for explanations or additional information. All personnel who work, or are planning to work, with [radioactive materials] radiation sources are responsible for knowing and adhering to the sections of this manual that are applicable to their work. It is the users' responsibility to be aware of the hazards associated with the use of radiation and to obey all SUNY – New Paltz, State, and Federal Regulations concerning radiation doses received by occupationally exposed personnel and the general public. This Manual (based on regulations published by the NYS Health Department, Bureau of Environmental Radiation Protection) is a description of practices and regulations regarding the safe handling and use of [radioactivity] radiation sources; all requirements and regulations stated in the Manual must be obeyed. Failure to do so is a citable violation and could result in loss of the privilege to use ionizing radiation for the user. Repeated violations or departures from the approved procedures jeopardize any use of ionizing radiation at SUNY – New Paltz.

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EMERGENCY TELEPHONE NUMBERS

	Ext.	After 5pm
RADIATION SAFETY OFFICER		
Jennifer Waldo CSB 226 / CSB 106	3698 / 3760	2222
ASSISTANT RADIATION OFFICER		
Laurence E. Rowe WSB 130	3747	2222
UNIVERSITY SAFETY OFFICER		
Michael Malloy Environmental Health and Safety SB 10	3310 / 3301	2222
UNIVERSITY POLICE		
SB 104	2222	2222
ALL EMERGENCIES (SUNY-NP Police Dispatcher)		
Calling from a campus phone	911	911
Calling from a cell phone or outside line	257-2222	257-2222
UTILITY OUTAGES (Facilities Services)	3301	3227

See next page for "NYS Standards for Protection Against Radiation" sign. A copy of this sign provided by the RSO **must** be posted in a conspicuous location in each laboratory utilizing radioisotopes or ionizing radiation.

In the event of a fire, explosion or other serious incident with radioactive or hazardous materials, call the SUNY – New Paltz University Police as soon as possible (911 on a university phone) and BE PREPARED TO PROVIDE THE DISPATCHER WITH THE FOLLOWING INFORMATION-BUT DO NOT DELAY AN EMERGENCY CALL TO ACCUMULATE THIS INFORMATION:

Location of the fire/incident:	(BUILDING & ROOM/LAB NUMBER)
Hazardous materials involved:	(RADIOACTIVE MATERIAL/NAME/TYPE,ETC.)
If medical assistance is needed:	(TYPE & NUMBER OF INJURED)

SECTION I
GENERAL INFORMATION

A. RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER, PRINCIPAL INVESTIGATORS, SUPERVISORY PERSONNEL, INDIVIDUAL LABORATORY USERS

1. RESPONSIBILITIES OF THE RADIATION SAFETY OFFICER INCLUDE:

a. Reviewing all proposals (see page 16) for use of radioactive material and other radiation sources; and approving or disapproving them in conjunction with the Radiation Safety Committee.

b. Inspecting facilities and equipment.

c. Prescribing special conditions and requirements as may be necessary for safe and proper use of all radiation sources.

d. Acting as consultant in the design of all new facilities using radiation sources, or constructed for the purpose of providing protection against radiation exposure.

e. Preparing and disseminating information on radiation safety for the use of and guidance of staff and students.

f. Supervision of SUNY – New Paltz training on radiation safety. (See appendix B)

g. Receiving, storing, processing, and dispensing radioactive material, and maintaining records on all of the preceding transactions.

h. Supervising, packaging, monitoring, and recording the disposal of radioactive waste.

i. Performing radiation surveys and monitoring all facilities in which radiation sources are used, or radiation-producing equipment resides. Surveys include, but are not limited to, contamination and record checks.

j. Monitoring and ensuring effluent releases are below regulatory requirements and taking corrective action, if required, to assume compliance with the regulations.

k. Providing personnel monitoring services, including the reviewing and recording of commercially processed film badge reports.

l. Ensuring that radiation safety guidelines and requirements are followed in the laboratories utilizing radioisotopes or ionizing radiation.

m. Preparing license applications, amendment applications, and required reports as well as acting as the contact point for all correspondence with State and Federal radiation health agencies.

n. Investigating radiation exposures, incidents, and accidents and reporting corrective action to the principal investigator, supervisory personnel, and Radiation Safety Committee.

o. Performing an annual Radiation Protection Program audit and reporting the results to the Radiation Safety Committee.

p. Ensuring that the Radiation Safety Committee formally meets each Fall and Spring semester as required by our License.

2. RESPONSIBILITIES OF PRINCIPAL INVESTIGATORS AND SUPERVISORY PERSONNEL

Members of the faculty or staff supervising the work of others, either in a teaching capacity, as a principal investigator, or in an administrative supervisory position, are responsible for ensuring that those under their supervision:

a. Discharge the individual responsibilities as listed in this manual.

b. Receive appropriate orientation and training as to the proper and safe use of radiation sources. This will require adequate planning. Before an experiment is performed, the supervisor should determine the types and amount of radiation or radioactive material to be used. This will generally give an indication of the protection required. The procedures to be followed must be well outlined. In many cases, before the procedure is actually performed with radioactive materials, it should be rehearsed in an attempt to preclude slip-ups or unexpected circumstances. In any situation where there is appreciable radiation hazard, the Radiation Safety Officer should be consulted before proceeding. Radiation User Training is available for all personnel handling radioactive materials and arrangements shall be made through the Radiation Safety Officer.

c. Complete Radiation User Training. This is required for all personnel handling radioactive materials. Arrangements are made through the Radiation Safety Office. New employees and/or students who have taken a similar training can be excused if they provide documentation indicating that the training covers NYS regulations. Taking Radiation User's Training at SUNY – New Paltz is an acceptable substitute. Failure to complete the training satisfactorily will prevent an individual from handling radioactive materials at SUNY – New Paltz. . Non-radiation workers need to know enough to safely conduct themselves in the specific laboratory environment. Admonishing non-radiation workers to avoid touching marked items/areas or lingering near posted areas is usually sufficient if other policies in this manual are rigorously followed.

d. Have knowledge of the harmful effects of radiation to which they may be exposed.

e. Are instructed in safe techniques, the application of approved radiation safety practices and the proper use of radiation detection instruments.

f. Have thorough knowledge of this manual and the regulations the manual requires.

They are further responsible to ensure that:

g. All radiation sources under their control have been properly approved and that all potential hazards are brought to the attention of the Radiation Safety Officer.

h. Appropriate radiation surveys are conducted.

i. Experiments or procedures using ^{125}I, ^{131}I, radioactive gases, labeled DNA precursors and/or labeled materials that have radioactive levels of 100 mCi or more are performed in a fume hood specifically identified for this purpose. Prior approval by the Radiation Safety Officer and Radiation Safety Committee must be obtained for these experiments to insure compliance with the New York State Department of Health regulations regarding effluent release of radioactive materials.

j. All necessary records are maintained.

k. The Radiation Safety Office is notified when new personnel are added or (in advance) when personnel under their supervision terminate (or, in the case of students, conclude activities that involved radiation).

l. Local laboratory safety procedures are established, with the assistance of the Radiation Safety Officer if necessary.

m. Areas and materials are properly posted and labeled, and that are secured against unauthorized removal.

n. Prepare and maintain a written laboratory procedure for handling isotopes particular to their lab and provide a copy to the Radiation Safety Office.

o. Those directly or indirectly under their supervision are provided equipment and training as required for their specific location and use.

p. Prevent unauthorized access to and removal of isotopes by assuring that personnel are following required security measures. Notify the Radiation Safety Officer before vacating premises to allow a thorough closeout survey before the premises are cleaned or occupied by anyone else.

3. RESPONSIBILITIES OF INDIVIDUAL LABORATORY USER

Individuals are responsible for:

a. Following generally accepted procedures of safe practice such as those specified in this manual.

b. Knowing and adhering to the sections of this manual that are applicable to their work.

c. Knowing and adhering to the specific laboratory procedures as documented in the initial proposal (p. 16) submitted to the Radiation Safety Officer for evaluation and approval.

d. Keeping exposures to radiation as low as possible.

e. Wearing appropriate film badges and strictly following the regular badge change schedule.

f. Immediately reporting to the Radiation Safety Officer any suspected exposure in excess of permissible limits.

g. Reporting any contamination to a monitorto prevent any cross-contamination of other monitors.

h. Wearing appropriate protective clothing and using proper techniques and facilities in operations involving radioactive materials.

i. Monitoring for, and removing radioactive contamination before leaving the lab.

j. Reporting wounds involving radioactive materials, inhalation or ingestion accidents and spills promptly to the Radiation Safety Officer.

k. Cleaning up contamination for which they are responsible after first having consulted with the Radiation Safety Officer if necessary.

l. Proper storage and labeling of radioactive materials for which they are responsible.

m. Packaging and labeling articles for waste disposal and maintaining records of such disposals.

n. Furnishing information to the Radiation Safety Officer concerning new activities in their area, particularly alterations of operations that might lead to personnel exposures or contamination.

o. Performing appropriate surveys for external radiation, decontamination and maintaining records of results or requesting assistance from the Radiation Safety Officer.

p. Contacting the Radiation Safety Officer before terminating employment or association with the University.

q. Assuring that acquisitions and transfers of radioactive materials are made in accordance with the provisions of this manual.

r. Complying with requests from the Radiation Safety Officer for bioassay. Requests for these tests will be made in the case of workers using significant quantities of radioisotopes.

s. Read and be knowledgeable about the lab procedure for handling isotopes particular to the labs they work in.

B. RADIATION SAFETY PROCEDURES

1. Radioisotope Safety Rules

The Safety Rules that are contained in this Manual are designed to protect four types of individuals:

a. Laboratory personnel - The people who work on a day to day basis in a laboratory that utilizes radiation sources, whether or not they actually handle the sources directly.

b. Faculty/staff personnel - The people who are responsible for supervision of laboratory personnel who handle sources of radiation and the University employees that must enter the laboratory containing radiation sources for maintenance and/or repair of facilities.

c. Students - The people who are being trained in the laboratory setting, whether or not their training/education program directly deals with the handling of radiation sources.

d. Other persons - The people who are internal or external to the University, who, without knowledge or permission, may be exposed to radiation.

2. Survey Procedures

a. Handling of radioactive materials in the form of gases, solutions and/or solids in the laboratory necessitates both radiation surveys and contamination surveys to prevent unnecessary radiation exposure to laboratory personnel and students. Furthermore, these surveys are required to prevent the spread of radioactive contamination throughout SUNY – New Paltz. Radiation surveys are performed by using a radiation survey meter and contamination surveys are performed by taking wipe samples from areas where work with radioisotopes is being done or where contamination is suspected.

b. In unrestricted areas radiation levels must be controlled so that a person cannot exceed dosage levels of reasonably 100 mR/yr or 2 mR/hr. For restricted areas, radiation levels should be as low as achievable with adequate shielding. (ALARA)

c. Wipe samples indicating ≥ 1000 disintegrations per minute (dpm)/100 cm^2 must be cleaned until the contamination is removed. Since this level is sometimes difficult to establish, whenever a wipe sample shows a detectable amount of activity above background, the area should be cleaned.

3. Personnel Monitoring - Badges and Thermoluminescent Dosimeters

a. Employment of a dosimeter requires consideration of the properties of the radiation, the level of potential exposure, and the complexity of the application.

b. Commercial badge services now make it technically feasible to obtain reliable readings at exposure levels down to 1 millirem. Although exposure at this low level is not very significant, monitoring may be provided to help the user practice ALARA in routine operations or document exposure during an accident. . Also to be noted, alpha, low-energy beta radiations (e.g. ^{3}H and ^{14}C), and neutrons of certain energies are not detected by film, Luxel, or TLD badges.

c. Any person likely to receive 10% or more of the applicable annual allowable dose limit is required to utilize a dosimetry badge or an appropriate monitoring device.

Examples of activities that may result in such doses include:

1) Any person working with millicurie amounts of a beta emitter with energies greater than 1 MeV.

2) Any person working with greater than 10 mCi of a gamma emitter with an energy less than 100 keV.

3) Any person working with millicurie amounts of a gamma emitter with energies greater than 100 keV.

4) Any person working with a hard beta emitter or a gamma emitter in millicurie amounts.

d. In order to obtain meaningful information from the use of a badge, the following guidelines must be observed.

1) Adopting the Appropriate Badge:

a) The Radiation Safety Officer will prescribe the appropriate types of monitoring device and change frequency for the conditions to be encountered.

b) Types of dosimetry devices used to monitor whole body exposure include beta-gamma x-ray, and neutron beta-gamma x-ray dosimeters. Thermoluminescent (TLD) dosimeters are used for monitoring exposure to hands or wrists. Luxel or TLD dosimeters are required for persons who routinely handle millicurie quantities of gamma emitters or highly energetic beta emitters such as ^{32}P. Both types of dosimeters are processed quarterly.

c) **NOTE: A badge or dosimeter should be processed immediately whenever an unusual or excessive exposure is suspected.** Call the Radiation Safety Officer if such circumstances arise.

2) Proper Use of the Badge:

a) Only the person who is assigned a badge should wear it. Do not loan a badge or use it for monitoring an area.

b) It is essential to monitor the portion of the body receiving the highest exposure to which whole body limitations apply.

4. Leak Tests of Sealed Sources

All nonexempt, licensed, sealed sources over 100 µCi will be examined and wipe tested every month (or more frequently if requested by the user) by a firm licensed by SUNY - New Paltz to measure for leakage. Sealed sources must be shown to exhibit removable levels of less than 0.005 µCi.

5. Bioassays

a. The Radiation Safety Officer will perform all bioassays in accordance with the conditions of the University's license, or when ingestion or inhalation of radioactive materials is suspected. Any significant, positive results will initiate an investigation of the working conditions and the work habits of the individual. Follow-up bioassays will be performed as required by the situation. The reports of the bioassay become part of the individual's exposure history and are kept on file in the Radiation Safety Office.

b. Persons handling 100 mCi of tritiated (^{3}H) material will submit a urine sample within twenty-four hours to determine tritium levels. Persons handling unbound radioactive iodine are required to contact the Radiation Safety Officer regarding the thyroid bioassay program. A baseline level is necessary, consequently one must be obtained prior to initiation of work with unbound iodine. Periodic checks will be performed to determine any uptake and compared to established action levels.

6. Exposure Limits for Radiation Workers

a. The maximum permissible dose limits as per NYS Department of Health 10 NYCRR Part 16 are specified in the following table:

Annual Limits for Adults

1)	The total effective dose equivalent being equal to: or;	5 rem
2)	the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to:	50 rem
3)	a shallow does equivalent to the skin or to any extremity of:	50 rem
4)	an eye dose equivalent of:	15 rem

b. Additional recommended limits for special situations include:

1)	Fetus during entire pregnancy not to exceed:	0.5 rem
2)	Students under 18 years old are not exceed 10% of the annual adult dose limits.	

C. BASIC PRINCIPLES AND GUIDELINES IN RADIATION PROTECTION

1. Biological Effects of Radiation

If an organism is given a significantly large dose of ionizing radiation within a relatively short period of time, there will be definite effects due to the irradiation. For example, a dose of several hundred rads delivered rapidly to the whole body of a mammal produces the "acute radiation syndrome" with severe illness or possibly death. Exposures of less than that required to produce the acute radiation syndrome may still produce genetic effects and will affect growth and development, the incident of neoplasms, and the life span.

These effects have been observed at doses greatly in excess of those presently recommended by national, state and local radiation protection agencies. At the present acceptable levels of radiation exposure, no cellular changes in mammals can be detected. There is no lower level to the amount of radiation that can produce gene mutations.

All these aspects of radiation damage were taken into consideration when the National Council on Radiation Protection and Measurements (NCRP), the unofficial authority on radiation protection, established recommended maximum permissible dose (MPD) values for different segments of the population. The primary objective in establishing MPD values for a person who works with radiation in his occupation is to keep his exposure well below a level at which adverse effects are likely to occur during this lifetime. Another objective is to minimize the incidence of genetic effects for the population as a whole. These dose limits do not include any dose received by an individual as a patient or the dose from natural background radiation.

It must be emphasized that the risk to individuals exposed to an MPD or the dose limits for the population is considered to be very small; however, <u>risk increases with increasing dose</u>. For this reason, it is desirable to keep radiation exposures as low as practicable with due consideration to medical objectives, feasibility, and efficiency of operation. For the same reason, small deviations in the exposure of an individual above prescribed levels are unimportant except as an indication of inadequate protection practices.

2. Basic Principles

It is the responsibility of any person involved in radiation procedures to minimize his or her own exposure to as low as reasonably achievable (ALARA). The following principles, which apply to whatever form of radiation or radioactive material is present, will help personnel reduce their exposure to levels that are ALARA.

a. <u>Distance</u>:
Radiation exposure is inversely proportional to the square of the distance from the source; thus, maintaining a large distance from a source of radiation offers a very practical avenue of protection.

b. <u>Time</u>:
Since accumulated dose is directly proportional to time, the less time one spends around radiation, the less radiation exposure one receives.

c. <u>Shielding</u>:
Shielding offers a form of protection that requires prior planning and anticipation of safety requirements for given work. Protection offered by shielding depends on the following:
1) Initial radiation dose rate without shield.
2) Material used for shielding -- the denser the material, the better it is as a shield.
3) Thickness of the shield.
4) Type and energy of radiation.

3. Calculation of Exposure and Dose Rates

a. Approximate Exposure Rate From Gamma-Emitting Point Source

$$\text{mR/hr at 1 foot} \simeq 6\ \text{CEn}$$

where: C = activity in millicuries
E = gamma ray energy in MeV
n = gamma quanta per nuclear transformation

b. Exposure Rate From Gamma Point Source

$$\text{mR/hr} = 10^3\ N\ \Gamma\ d^{-2}$$

where: N = activity of source in millicuries
Γ = gamma dose rate constant for that nuclide in R/hr-mCi at 1 cm (see Table 1, p.12)
d = distance from source in centimeters

c. Approximate Dose Rate From a Beta Point Source

$$\text{mrads/hr} = 3.1 \times 10^5\ N\ d^{-2}$$

where: N = the activity of the source in millicuries
d = distance from the source in centimeters

(SEE NOTES, TOP OF NEXT PAGE)

Notes on Approximate Dose Rate From a Beta Point Source

1) The maximum energy of the beta particles must be 0.5 MeV.

2) d must be small with respect to the maximum range of the beta particles in air; otherwise, there will be absorption. The dose rate thus derived will be conservatively high from the radiation protection standpoint.

d. Relationship Between Exposure Rate and Distance From Source

$$\frac{I_1}{I_2} = \frac{(d_2)^2}{(d_1)^2}$$

where: I_2 = exposure (dose) rate at distance d_2
I_1 = exposure (dose) rate at distance d_1
(The distances must be in the same units)

e. Radioactive Decay

$$A = A_o e^{-kt}$$

from which, $\ln(A) = \ln(A_o) - kt$, $\ln(A/A_o) = \ln(e^{-kt})$

where: A = activity remaining after the time interval t
A_o = activity at some original time
e = base of natural logarithm system = 2.7183
$\ln$ = natural logarithm
t = the elapsed time
k = the decay constant for a particular radionuclide

$k = \ln 2 / t_{1/2}$
$\ln 2 = 0.693$
$t_{1/2}$ = the physical half-life of the radionuclide

NOTE: $t_{1/2}$ and t must be in the same units.

4. Gamma Dose Rate Constants For Selected Nuclides

TABLE 1
GAMMA DOSE RATE CONSTANT (Γ) FOR SELECTED NUCLIDES*

Nuclide	Γ	Nuclide	Γ	Nuclide	Γ
Antimony-124	9.8	Indium-111***	3.24	Rubidium-86	0.5
Barium-133	2.4	Indium-113m***	1.77	Scandium-47	0.56
Beryllium-7	0.3	Indium-114m	0.2	Selenium-75	2.0
Bromine-82	14.6	Iodine-123***	0.67	Silver-110m	14.3
Carbon-11**	5.9	Iodine-125***	1.5	Sodium-22	12.0
Cesium-137	3.3	Iodine-131	2.2	Sodium-24	18.4
Chromium-51	0.16	Iridium-192	4.8	Strontium-85	3.0
Cobalt-57	0.9	Iron-59	6.4	Tantalum-182	6.8
Cobalt-60	13.2	Manganese-54	4.7	Technetium-99m	0.7
Copper-64	1.2	Mercury-203	1.3	Thallium-170	0.025
Gallium-67	1.1	Molybdenum-99	1.8	Tin-113	1.7
Gallium-72	11.6	Potassium-42	1.4	Xenon-133	0.14
Gold-198	2.3	Potassium-43	5.6	Zinc-65	2.7
		Radium-226	8.25		

Reference:
*Jaeger, R.C., et al., Engineering Compendium on Radiation Shielding, Vol. 1, (New York: Springer-Verlag, 1968), pp 21-30.

Γ is given in R-cm^2/hr-mCi = 10× Γ in units of R-m^2/hr-Ci (see below)

**A Manual of Radioactivity Procedures (National Bureau of Standards Handbook No. 80 (Washington, D.C.: Supt. of Docs., U.S. Government Printing Office, Nov. 1961), Appendix A, pp. 137-140.

***Stanford University, Health Physics

In order to derive the exposure rate in terms of R per hour per curie at one meter, the above Γ values in the table should be divided by 10.

5. Shielding of Gamma Radiation Sources

$I = BI_oe^{-\mu x}$ $\quad I = I_o B e^{-\mu x}$

where: B = build up factor (dependent upon composition of shielding, the energy of the gamma radiations and the thickness of shield). See Radiological Health Handbook, 1970 Edition, PHS Publication No. 2016.

I_o = the original exposure rate

e = base of natural logarithm system = 2.7183...

x = the shield thickness

μ = the linear absorption coefficient (reciprocal units of the shield thickness)

NOTE: $\mu = (\mu_{a/\rho})\rho$

where: $\mu_{a/\rho}$ is the mass absorption coefficient.
See NSRDS-NBS Report No. 29 for values of $\mu_{a/\rho}$

ρ = the density of the shielding

or

$\mu = \ln 2/x_{1/2}$

where: $\ln 2 = 0.693$

$x_{1/2}$ = the amount of shielding that will reduce the radiation intensity by half.

SECTION II
UNIVERSITY REGULATIONS APPLICABLE TO THE USE OF [RADIOACTIVE MATERIALS] RADIATION SOURCES

A. AUTHORIZATION TO USE RADIATION SOURCES

1. Approval to use radiation sources is obtained in the following manner:

a. A memorandum must be sent to the Radiation Safety Officer covering the following items in the order listed:

1) Name and title of applicant (project supervisor).

2) Curriculum Vita

3) Building and room. Include a SKETCH (building drawings can be obtained from ARSO) of the room showing facilities to be used.

4) Names and titles of technically-trained faculty or staff or students participating in the project (excluding students enrolled in courses). Note the completion date of the SUNY - New Paltz training or equivalent.

5) If material is to be used in class work, indicate whether persons under 18 years of age may be present and the anticipated exposure. Also arrange for class to take training.

Is radioisotope covered by license; if not, amendment needed to license. (See RSO)

6) a) [Radioisotope(s)] The source of radiation, if a radioisotope, then:
b) Chemical form
c) Maximum quantity to be used per experiment and frequency of experiments.
d) Maximum quantity to be obtained per order
e) Maximum to be possessed at any time
f) Estimate potential exposures to gamma and strong beta emitters, (use the information provided in this manual).

7) Proposed use. Briefly outline the procedures to be followed; describe the procedures to be followed in sufficient detail to permit a radiation safety evaluation to be made by the Radiation Safety Officer and Radiation Safety Committee. **Allow sufficient time for this review**.

8) List protective equipment (e.g., fume hoods, shielding, etc.) to be used. Include plans for handling and storing radioactive materials, disposal of radioactive wastes, etc. Also, list survey instruments that are available for personnel protection. As a matter of policy, each project is required to have

at its disposal suitable monitoring instrumentation for detection of the radiation that may be present in the laboratory.

9) If a fume hood is to be utilized, a detailed protocol is required and must include:

a) Isotope, maximum activity in the experiment, frequency of experiment.

b) Physical and chemical form(s) of the isotope during the experiment.

c) Procedure for monitoring the effluent (and/or containment)

d) Estimated minimum and maximum effluent given off during the experiment.

NOTE: A specially designated fume hood must be utilized for iodination experiments involving ^{125}I, ^{131}I, radioactive gases, labeled DNA precursors and/or labeled materials in excess of 100 mCi (see section I.B.i of Responsibilities of Principal Investigators and Supervisory Personnel, p.3).

10) If this is a first experiment, give a brief but explicit description of the previous experience and training in the fields of technology required by the experiments for the persons named above. Particularly, emphasize experience with and knowledge of radiation.

11) Enumerate safety considerations that are involved and the measures that will be taken to implement radiation safety. Indicate how possible personnel and facility contamination will be assessed.

2. Approval for a project generally will be for a period of one year. At the end of this period, the project supervisor will have an opportunity to up-date the application. The Radiation Safety Officer will apprise the project supervisor of the information required.

3. Please note that the above information is not only required for internal SUNY - New Paltz review. This information is also required by the licensing division of the NYS Department of Health, Bureau of Radiation Control and is forwarded to them for final approval. **No one at SUNY - New Paltz may order radioactive materials unless they have been approved and placed on SUNY - New Paltz Radiation License.**

B. ACQUISITION OF RADIATION SOURCES

1. Purchase of Radioactive Materials

Radioactive materials may be ordered only by persons who have obtained official authorization to use such materials. Official authorization constitutes acceptance of the individual by the NYS Bureau of Radiation Control and listing on the Radiation License for SUNY - New Paltz. All purchase requests for radioactive materials must be submitted to the Radiation Safety Officer for approval. Providing the amount of material requested does not exceed the authorized inventory level for SUNY - New Paltz and the isotope is approved on the Radiation License, the purchase request will be signed by the Radiation Safety Officer and the License number will be added. Without this approval the Purchasing and Accounting departments will not process the purchase order.

2. Receipt of Radioactive Materials

a) Inspection by RSO. After receipt of radioactive materials by The University's Central Receiving, the Radiation Safety Officer will be notified. The packing slip of all packages received will be examined to determine that the correct isotope, chemical form, and amount of material has been received. All packages will be examined for signs of damage, such as being crushed, open, or wet. All packages will be surveyed for external radiation levels with a hand-held meter equipped with a thin end-window G-M probe or a NaI crystal detector. Radiation levels must not exceed 200 millirems/hr at the surface or 10 millirem at 1 meter. Efficiency of detection of a given isotope, based on calibration results and manufacturer's instructions must be taken into account when evaluating radiation levels observed with a hand-held meter. Since a survey meter will not readily detect low levels of removable contamination from weak beta or gamma emitters, all packages will also be wipe tested at various locations over a total of ~300 cm^2 for removable external contamination. These wipe tests will be analyzed. When the package is certified as acceptable, the authorized user requesting the material will be notified. The Radiation Safety Officer will deliver the package to an authorized use location. The user will be responsible for inspecting the contents inside the package once it has been transported to the user's area and certifying the actual contents. For packages that are damaged and contaminated or exceed the limits on external radiation or removable contamination, the package will be held for return and the final delivery carrier and the Bureau of Radiation Control will be immediately notified by telephone and in writing (e.g., facsimile). The Radiation Safety Officer will make special arrangements for after-hours receipt or for redelivery the next business day of any packages that fail to arrive during normal business hours (the expected delivery date is requested of all shippers to facilitate identification and interdiction of potential late delivery packages).

b) Opening and inspection by user. The user will put on gloves to prevent hand contamination. The package will again be inspected for signs of visible damage at the point of opening and the RSO will be notified if damage is observed at any time during opening and no further handling will be done. The radiation level at 1 meter and the package surface will have already been checked by the RSO but the user may wish to confirm the determination of the RSO. For Yellow II and Yellow III labeled packages, the dose rate expected at 1 meter from the package surface is that indicated by the "transport index" on the label. The dose rate at the surface should not exceed 200 mR/hr. The dose rate for "White I" labeled packages should not exceed 0.5 mR/hr at the surface. If external radiation levels are greater than expected or exceed these limits, stop and notify the RSO. Open the inner package and verify that the contents agree with the information provided and the material ordered. Check the integrity of the final source container. Look for broken seals or vials, loss of liquid, condensation, or discoloration of the packing material. If anything is other than expected, stop and notify the RSO. Perform a wipe test on the final source container. Until the results of the wipe test are obtained, assume that the materials received may be contaminated and take precautions to prevent the potential spread of contamination. Monitor the packing material and the empty packages with a survey meter before discarding. If contamination is discovered for any packing material, it must be treated as radioactive waste. If not contaminated, remove or obliterate all radiation labels before discarding in in-house trash. DO NOT DISCARD NON-RADIOACTIVE MATERIALS IN RADIOACTIVE WASTE. Record the amount and type of radioisotope received and begin a log for the material in that package.

3. Acquisition of "No-Charge" Radioactive Materials

The Radiation Safety Officer must be notified and give approval <u>prior</u> to the acquisition of "no-charge" radioactive materials. Only those persons with official authorization may obtain such materials if there is an immediate need and the material will not become a disposal problem.

4. General License Materials

For research or diagnostic purposes small quantities of certain isotopes can be purchase without a specific license. However, these General Licence materials are subject similar requirements for record keeping, contamination control, and waste disposal accounting. Therefore, no General License Material should be acquired or disposed of without the Radiation Safety Officer's approval.

5. Anyone obtaining an x-ray machine or other equipment that contains a source must receive prior approval from the Radiation Safety Office.

C. ACCOUNTABILITY FOR RADIATION SOURCES

1. Locations of Use

Radiation Sources may only be used in those facilities that have been approved by the Radiation Safety Officer. Investigators wishing to expand their areas must submit an application that includes a description of the area (fixtures, storage, etc) and any other required facilities. Moving to a new area requires a decontamination procedure and notifying the NYS Health Department. (See RSO)

2. Transfer of Radiation Sources

There are a variety of circumstances that may arise on campus making it desirable to transfer radiation sources from one laboratory to another. Since the Radiation Safety Officer <u>must</u> be informed of the status of radiation use in all campus areas at all times, the following general procedures must be observed.

a. <u>On Campus Transfer</u>. The transferor must inform the Radiation Safety Officer to assure that the recipient has been authorized to use the specific radiation source being transferred. Submit following information to the Radiation Safety Officer for advance approval. Transfer, especially between floors or buildings, must be done by the Radiation Safety Officer.

1) [Radionuclide] Source to be transferred

2) Chemical and physical form

3) Activity (in microcuries)

4) Name and division of transferor

5) Name and division of recipient

b. Off Campus Transfer. Consult the Radiation Safety Officer for the procedure to be followed. It is necessary to arrange in advance receipt of the material at its destination and proper transportation requirements must be met depending upon the radioactive material to be shipped. The Radiation Safety Officer will coordinate with Central Receiving to prepare materials for commercial transportation. Private transportation is not allowed and might cause serious liability.

3. Disposal of Radioactive Wastes

a. All potentially contaminated materials should be considered radioactive unless a survey of the material reveals no contamination detectable with instrumentation of adequate sensitivity.

b. All waste, liquid and solid, must be disposed of in appropriate waste containers. Liquid waste must be contained in tightly-capped plastic or glass containers where appropriate. The principal investigator is responsible for insuring that liquid scintillation fluid is emptied into the liquid waste carboy and the emptied plastic or glass vials are disposed of in their cardboard trays or plastic bags. Attempts should be made to separate aqueous from organic wastes. Label all waste containers "Caution -- Radioactive Material" with the legal symbol and record the isotope, quantity in microcuries, and date. Logs are provided on waste containers, and appropriate entries are made by the principal investigator each time waste is disposed.

c. In order to dispose of radioactive waste the principal investigator or representative should contact the Radiation Safety Office for pickup of the materials. Disposal of radioactive wastes without prior contact of the Radiation Safety Officer is not permitted. No one may enter the waste disposal room without the Radiation Safety Officer's knowledge and permission. The RSO is responsible for completing a Radioactive Materials Disposal/Transfer Form at the time of delivery of the radioactive materials for disposal at an authorized disposal site.

d. Liquid scintillation and some sources may be disposed of in the sink as per DEC and NYS regulations. (Contact RSO)

4. Log Notebook

a. Each individual laboratory must maintain a laboratory journal in which pertinent records are permanently filed and readily retrievable. This journal should be kept in as small a number of laboratory notebooks as will meet the needs of the project. This journal must be accessible to all persons who work with radiation sources under the project. The journal must include, but is not limited to, the following records:

   1) Correspondence with the Radiation Safety Officer.

   2) Receipt, utilization, and disposal of each radioactive source, shipment, etc. It is essential that these records account for the difference between radioisotopes on hand and those received.

   3) An inventory of sources on hand in the laboratory.

   4) Instrument surveys and results of wipe tests for removable contamination -- specify the date, the person making the survey, the instrument used, including serial number, model number and the location and levels of radiation and contamination encountered. It is important that a statement regarding the average exposure reading encountered in work areas be included in the record even when this value is essentially background. Causes of high survey readings should be determined (with the assistance of the Radiation Safety Officer if necessary) and be eliminated.

   5) Results of any sealed-source leak tests pertaining to any sources in the laboratory.

   6) Additional miscellaneous entries in the journal should include the addition or deletion of personnel from the project staff, significant instruction or information programs carried out for or attended by students or technical assistants, and accidents or instances of contamination together with a description of corrective efforts.

b. Inventory control forms must be filed with the Radiation Safety Officer whenever requested.

c. The Radiation Safety Officer must be notified at once whenever radiation sources have been lost or misplaced.

D. RADIATION SURVEYS

Good laboratory practice dictates that radiation surveys be made during and after experiments and routinely thereafter to ensure that sources are adequately shielded and that contamination is controlled.

1. Instruments

Two types of portable instruments are commonly used to make radiation surveys and evaluate levels of contamination (except for ^{3}H contamination). One is the air-filled ion chamber and the other is the G-M counter.

a. The air-filled ion chamber measures the number of ions produced in a confined air volume by collecting the ions as a current across an electrical potential. Such instruments accurately measure the exposure rate with minimal dependence upon the energy of gamma radiations. They are principally effective for measuring fields of radiation around gamma sources. Widespread contamination can also be easily detected because of the large volume of the detector. It is very difficult to detect less than 0.1 mR/hr on the most sensitive of these instruments. With suitable thickness of windows these instruments can detect beta and alpha radiations. Interpretation of readings from the latter radiations in mRad/hr is complicated. Usually such readings should be taken merely as indications of contamination.

b. The Geiger-Mueller (G-M) Counter is more sensitive than the ion chamber. Exposure rates as low as 0.01 mR/hr can be detected. Thus G-M instruments are suited to checking for contamination on one's clothing and body as well as in work areas. G-M instruments have detectors filled with a gas other than air and thus do not read exposure rates (roentgens/hr) directly. Radiations cause electrical discharges in the G-M detector tube. These discharges are converted to electronic pulses (counts) per minute (or second) and are read on a meter. The sensitivity varies markedly with energy, so that an instrument calibrated with ^{137}Cs (0.662 MeV gamma) radiations will markedly overrespond to lower energy radiations (by as much as a factor of 6 for 0.06 Mev radiation). A G-M counter used on campus should be equipped with a thin side window G-M tube to permit detection of low-energy beta radiations, e.g., ^{14}C. Efficiency of detection of a given isotope, based on calibration results and manufacturer's instructions must be taken into account when evaluating radiation levels observed with a hand-held meter. Because low-energy gamma or x-rays may be detected **very inefficiently** by a G-M probe, better sensitivity may be obtained by employing a scintillation probe with a NaI crystal (**up to 100× better sensitivity**). G-M counters should also be equipped with a speaker or other audible indicator, to allow one to survey without watching the meter -- this is a unique advantage
of the pulse counting system. Because of the randomness of radioactive decay, the meter reading at low count rates often fluctuates widely. For this reason, the audio speaker is sometimes a better indicator of small amounts of radioactivity than the meter reading. At higher count rates, the speaker response is often faster than the meter reading. It is better, therefore, to have the speaker on when using a G-M counter. Most G-M counters can become paralyzed in moderately high radiation fields, greater than a few R/hr. This is a serious problem when millicurie amounts of

isotopes -- especially ^{32}P -- are present. The paralyzed instrument may give a zero reading in such a field. Turn on the meter before entering a radiation area.

c. When making surveys use either type of instrument with window shield in proper position, "open" if beta contamination is suspected, "closed" if checking gamma or x-ray exposure rates only. Be sure instrument is calibrated annually or after major repairs are made. Be sure to know what the characteristics of the instruments are (review the manual). Use the instrument carefully -- most instruments have slow response when surveying low radiation intensities, such as when surveying for low-level contamination. The detector must be moved slowly and held close to the surface being surveyed. Avoid contaminating the instrument or breaking the thin window of the detector. Always use the thin end-window for detecting pure beta emitters and low-energy photons (e.g. ^{32}P, ^{35}S, ^{14}C, ^{55}Fe, ^{125}I, and x-rays less than 40 keV). Very low-energy beta emitters such as ^{3}H and ^{63}Ni are not detectable since their betas do not have enough energy to penetrate the window. They are best detected by using liquid scintillation counting techniques. ^{14}C and ^{35}S emit betas energetic enough to pass through the thin window. However, covering the window with plastic wrap or paraffin film, sometimes done to prevent probe contamination, will stop most or all of their betas from entering the detector. The efficiency of a meter for a specific source of radiation is given by the ratio of the meter count rate to the actual disintegration rate of the source (cpm/dpm). Some examples of approximate G-M efficiencies through the end-window at 1 inch from a point source are given below. The efficiency of your probe and meter in detecting radiation can be determined from the manufacturer's instructions and periodic recalibration. The distance from the source and the nature of the source are very important.

Example only

^{3}H	not detectable
^{14}C, ^{35}S	0.2% - 0.8% *
^{32}P	3% - 8%
^{125}I	0.01% - 0.03%

* Not detectable if the detector window is covered with paraffin film, plastic wrap, or other material.

Example: Your G-M counter reads 5000 cpm at one inch from a small spot of ^{32}P contamination on the bench. What is the total activity of the contamination?

actual disintegration rate = (5000 cpm)/(0.05 cpm/dpm) = 100,000 dpm = 1700 dps = 1700 Bq = 45 nCi

Note that the exposure rate indicated on the meter (millirads/hr) is not accurate for particulate radiation, because almost every particle entering the detection chamber, no matter how energetic, is detected. Exposure rate is only accurate for penetrating gamma or x-rays after calibration and allowance for efficiency of detection.

d. Scintillation detectors that incorporate a sodium iodide crystal should be used for the detection of low-energy gamma emitters such as ^{125}I. Some survey meters allow the use of either a G-M detector or a scintillation detector. The efficiency of a low-energy scintillation probe for the detection of ^{125}I is about 5% at one inch from a point source-- over a hundred times better than a G-M probe. Use of a G-M probe may lead to the false conclusion that contamination is not present.

2. Smear Surveys

a. An effective method for surveying for removable contamination -- the only effective method of surveying tritium contamination -- is to take smears in work areas, on floors, etc., using filter paper or cotton swabs. A series of wipes should be taken from those surfaces where contamination is expected or where radiation levels are high. This can include, but is not limited to, incoming packages, areas where solutions are prepared, pipetting is performed, organic synthesis undertaken, etc. The wipes are numbered, labeled, and located on a sketch of the areas being examined. Wetting the wipes with water, acetone and/or alcohol is desirable. The wipes are then rubbed over a surface area of ~100 square centimeters. Count the smears in a suitable detection system (for ^{3}H, a liquid scintillation counter is usually the only suitable counter). The resulting counts give an indication of the levels of contamination. In keeping with the ALARA philosophy, detectable contamination should be promptly removed. If serious contamination, e.g., 50,000 dpm on a wipe, is found, call the Radiation Safety Officer for assistance.

b. Keep a record of results of surveys performed by the lab personnel in the laboratory journal. The Radiation Safety Officer makes periodic surveys of all laboratories where isotopes are used and issues written reports of results to the Project Director. Special surveys including air sampling surveys may be requested by experimenter when it is believed necessary.

3. Leak Tests on Sealed Sources

All nonexempt, licensed, sealed sources over 100 µC will be examined at one month intervals by ARSO. Examinations are conducted to ensure that sources do not exhibit leakage in amounts greater than 0.005 µCi. If a suspected problem occurs with a sealed source, contact the Radiation Safety Officer and arrangements will be made to test the source immediately.

4. Frequency of Surveys

a. The frequency of surveys depends upon the amount and type of radioactive material used. Listed below are examples that may be useful in determining how often to perform surveys. The greater the work load, the more often the surveys should be performed.

b. Low-Level Areas - Not less than once a week - Areas such as where in vitro tests are performed, samples analyzed, etc. (samples usually less than 100 microcuries each).

c. High-Level Areas - Not less than once a day - Areas used for storage of active solutions, preparation of materials, fume hoods, etc. (usually tens of millicurie amounts).

5. Acceptable Limits for Radioactive Contamination

a. Acceptable limits of contamination shall be as follows

1) In uncontrolled areas specifically designated for use of radioactive material by users only and not frequented by members of the general public (non-users of radioactivity), the continuous dose rate outside of shielding shall not be greater than 0.2 mrem/hr and removable contamination on designated work area surfaces shall not exceed 1000 dpm/100 cm^2 (beta-gamma) or 100 dpm/100 cm^2 (alpha)

2) In uncontrolled areas accessible to the general public (non-users of radioactivity) and not specifically designated for radiation use, radiation levels shall not exceed 2 millirem in any one hour and 100 millirem per year. Both limits must be observed and documented. Removable contamination will not exceed 100 dpm/100 cm^2.

b. In both cases calibrated instruments with known efficiency for radiation being detected must be used.

E. STANDARD METHODS FOR REDUCING EXPOSURE AND CONTAMINATION

1. Storage of Radioactive Materials

a. Locate storage shield in a place to cause minimal exposure.

b. Use adequate shielding -- exposure rate should not exceed 2 mR/hr at 30 cm from the shield. Don't forget areas behind the shield, or above or below. Make sure a bench top will support the weight of a shield and that shielding materials are secured so that they will not fall.

c. Provide a pan and absorbent pad to catch spillage.

d. Clearly identify each item in storage, use a mirror or transparent portion of shield to provide for visual inspection without exposure. If appropriate, provide a sketch of the storage layout showing where items are stored.

e. Compartmentalized shield (use partitions or smaller shipping shields) will reduce exposure to the aggregate of the sources.

f. Survey area periodically using an appropriate method.

g. Post storage areas as required.

h. Use a plastic box or other secondary container for items in storage in refrigerators and freezers.

i. Do not store food in areas (including refrigerator) where radioactive materials are stored.

j. Locate appropriate handling tools and supplies (remote pipette, propipette, tongs, gloves, etc.) conveniently.

k. Store radioactive liquids in unbreakable containers or in secondary containers to prevent spillage.

l. Shield radioactive wastes in storage, awaiting pickup, so that radiation levels at 30 cm for a box do not exceed 2 mR/hr.

2. Work Areas

a. Use absorbent pads or pans to cover work areas -- small, easily spilled containers need a stable work surface to prevent spillage -- pans are better for the latter purpose. Be careful not to create fire hazards.

b. Good housekeeping is required where radionuclides are used. Clean contaminated items as soon as possible. Change bench covering frequently enough to prevent external exposure from spots of contamination and to reduce airborne contamination from dried spills.

c. Provide adequate shielding -- radiation exposure rate should be less than 2 mR/hr at 30 cm from shields -- survey periodically using appropriate methods. Make sure that a bench will support the required shielding and that the shield is secured so that it will not fall.

d. Do not keep foods or beverages where unsealed radionuclides are present. Smoking, eating and drinking in laboratories is prohibited.

3. Handling

a. Wear appropriate protective clothing such as waterproof gloves and a lab coat when handling unsealed radionuclides. In some instances leaded aprons or other garments may be necessary or useful. Do not wear sandals or open-toed shoes. Wear socks.

b. Handle gamma and energetic beta-emitting sources and stock bottles using tongs or forceps. Crucible tongs, with rubber tubing on tips to increase gripping effectiveness, are usually quite good (and inexpensive) for handling such items in the laboratory.

c. Use remote or hand-controlled pipettes. <u>Mouth pipetting with all radioactive materials is prohibited</u>.

d. Use appropriate containment, e.g. fume hoods or glove boxes, for handling radioactive materials that may become airborne, such as dusts or vapors. Where radioiodine vapors are present, always use a fume hood that has a minimum average face velocity of 100 cubic feet per minute.

e. Never work with radioactive materials when open cuts may be contaminated.

f. Do not eat, drink, or smoke in areas where radionuclides are being used.

g. Be informed; know the mechanical, chemical and radiation hazards of the materials and operations that are to be performed. Frequently, it is useful to try a dry-run experiment to see if a radioactive experiment is feasible.

4. Posting and Labeling Requirements

a. Signs or labels are required for all levels of radiation and radioactivity.

b. Consult the Radiation Safety Officer for proper instructions for posting or otherwise controlling areas where radiation dose rates exceed 100 mR/hr, or where radioactive materials may be airborne.

c. The following are some of the general requirements for signs and labels. Signs are usually available from the Assistant Radiation Safety Officer.

Notice to Employees. Conspicuously post a current copy of NYS Department of Health Notice to Employees in a sufficient number of places to permit individuals working in or frequenting any portion of a controlled area to observe a copy on the way to or from such an area.

d. Standard radiation symbol. Unless otherwise authorized by the department, the symbol prescribed by this section shall use the colors magenta, or purple, or black on yellow background. The symbol prescribed is the three-bladed design and shall be as illustrated below:

(1) Cross-hatched area is to be magenta, or purple, or black, and

(2) The background is to be yellow.

(3) Exception to color requirements for standard radiation symbol. Notwithstanding the requirements, licensees or registrants are authorized to label sources, source holders, or device components containing sources of radiation that are subjected to high temperatures, with conspicuously etched or stamped radiation caution symbols and without a color requirement.

(4) Additional information on signs and labels. In addition to the contents of signs and labels prescribed in this Part, the licensee or registrant shall provide, on or near the required signs and labels, additional information, as appropriate, to make individuals aware of potential radiation exposures and to minimize the exposures.

e. (1) Posting requirements.

(i) Posting of radiation areas. The licensee or registrant shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, RADIATION AREA”.

(ii) Posting of high radiation areas. The licensee or registrant shall post each high radiation area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, HIGH RADIATION AREA” OR “DANGER, HIGH RADIATION AREA”.

(iii) Posting of very high radiation areas. The licensee or registrant shall post each very high radiation area witha conspicuous sign or signs bearing the radiation symbol and words “GRAVE DANGER, VERY HIGH RADIATION AREA”.

(iv) Posting of airborne radioactivity areas. The licensee or registrant shall post each airborne radioactivity area with a conspicuous sign or signs bearing the radiation symbol and the words “CAUTION, AIRBORNE RADIOACTIVITY AREA” or “DANGER, AIRBORNE RADIOACTIVITY AREA”.

(v) Posting of areas or rooms in which licensed or registered material is used or stored. The licensee or registrant shall post each area or room in which there is used or stored an amount of licensed or registered material exceeding 10 times the quantity of such material specified in Appendix 16-A, Table 9 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" OR "DANGER, RADIOACTIVE MATERIAL(S)".

(2) Exceptions to posting requirements.

(i) A licensee or registrant is not required to post caution signs in areas or rooms containing sources of radiation for periods of less than 8 hours, if each of the following conditions is met:

(a) The sources of radiation are constantly attended during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to sources of radiation in excess of the limits established in Part 16; and

(b) The area or room is subject to the licensee's or registrant's control.

(ii) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at 30 centimeters from the surface of the sealed source container of housing does not exceed 0.05 mSv (0.005 rem) per hour.

f. Labeling containers and radiation machines.

(1) The licensee or registrant shall ensure that each container of licensed or registered material bears a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". The label shall also provide information, such as the radionuclides present, an estimate of the quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials, and mass enrichment, to permit individuals handling or using containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.

(2) Each licensee shall, prior to removal or disposal of empty uncontaminated containers to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

(3) Each registrant shall ensure that each radiation machine is labeled in a conspicuous manner which cautions individuals that radiation is produced when it is energized.

(4) Exemptions to labeling requirements. A licensee or registrant is not required to label:

(i) Containers holding licensed material in quantities less than the quantities listed in 10 NYCRR Part 16 Appendices..

(ii) For laboratory containers, such as beakers, flasks, and test tubes, used transiently in laboratory procedures (i.e. for a period of a few hours) in the presence of an authorized user; or

(iii) Containers when they are in transport and packaged and labeled in accordance with the regulations of the U.S. Department of Transportation; or

(iv) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record. Examples of containers of this type are containers in locations such as water-filled canals, storage vaults, or hot cells. The record shall be retained as long as the containers are in use for the purpose indicated on the record; or

(v) Installed manufacturing or process equipment, such as chemical process equipment, piping, and tanks.

G. DECONTAMINATION

The primary focus of decontamination is the removal of as much contamination as possible with the minimum amount of radioactive waste byproducts.

Removal of radioactive contaminants falls into two categories: 1) decontamination of personnel and, 2) decontamination of facilities. The degree of contamination must first be determined by conducting a Radiation Survey consisting of a radiation level survey and/or a contamination level survey. If a radiation level survey in a uncontrolled radiation work area of a laboratory shows a continuous dose rate outside of shielding greater than 0.2 mrem/hr (7 mg/cm^2 side-window) or removable contamination greater than 1000 dpm/100 cm^2 (beta-gamma) or 100 dpm/100 cm^2 (alpha), decontamination is required. For other areas of an uncontrolled laboratory, other than designated radiation work areas radiation levels must not exceed 2 millirem in any one hour or 100 millirem per year and removable contamination must be less than 100 dpm/100 cm^2 as demonstrated by wipe survey

1. Personnel Decontamination

a. Prompt removal of surface contamination is necessary to prevent possible transfer of radioactivity to internal organs by ingestion, absorption, through wounds, cuts, or abrasions, and also to prevent possible radiation overexposure of the skin. It is imperative that the methods used to effect decontamination should not spread initially localized material or assist the contaminant in entering the body. <u>Report personnel contamination to the Radiation Safety Officer at once.</u>

b. The following procedures have been used for removal of a wide variety of contaminants from personnel. (More drastic methods must be performed only under medical supervision.)

1) Remove contaminated clothing and place it in a suitable container.

2) Monitor the person carefully to determine the level and location of contamination.

3) Decontaminate in the following manner:

a) First, if possible, use masking or adhesive tape to remove loosely attached contamination. Often most of the contamination can be removed in this manner without risk of spreading the material or dissolving it into the skin, as can happen with the use of solvents.

b) Secondly, if one knows a suitable solvent for the material (which is not injurious to the skin), this should be tried.

c) Thirdly, if the first method fails and there is no special solvent known (or the second method fails), cleanse the contaminated areas with mild detergent and water -- giving special attention to hair and fingernails.

d) <u>NOTE</u>: If the contamination is localized, it is often more practical to mask off the affected area before risking the danger of spreading the contamination by general washing.

e) If the procedures outlined above fail to remove the contaminants, soft brushes may be used for cleansing, but care must be taken to avoid use of abrasive or strongly alkaline cleansers that may allow the contaminants to penetrate the skin.

f) Use copious amounts of water. However, use caution to avoid contaminating minor cuts or breaks in the skin.

g) Where readily available, special (dry) hand cleaners may facilitate decontamination.

h) Apply hand cream or lanolin to the areas to prevent chapping.

4) If the contaminated individual also requires medical treatment, do not delay treatment. Provide guidance and assistance to the medical caregivers to contain the further spread of any contamination from the individual. Decontamination can proceed after the individual is treated or stabilized.

2. Facility Decontamination

a. Monitor to determine the level and location of contamination.

b. Post with appropriate signs to keep people out of area.

c. Mark off contaminated areas (masking tape is useful for this purpose).

d. Plan decontamination procedures -- obtain adequate supply of decontamination materials (see below).

e. Cover clean areas with paper or plastic sheeting to prevent spread of contaminants.

f. Wear protective clothing such as rubber gloves and shoe covers.

g. First remove "hot" spots, then work from the perimeter toward the center. Do not use excessive water since this may cause the contamination to run off. (See technique below).

h. Take care not to track contamination. Monitor all persons leaving contaminated area -- particularly check soles of shoes and hands.

i. Isolate and retain mops, rags, brushes, and wash solutions until these can be monitored for contamination.

3. Techniques

Techniques for removal of contamination from facilities are generally subject to consideration of the value of the contaminated items and the durability of the surfaces that are contaminated. A summary of techniques that have been successfully employed in decontamination of various materials follows.

4. Tools and Glassware

a. Decontamination methods fall into two broad classifications: corrosive and non-corrosive. It is always desirable to use a non-corrosive method, yet this is seldom practical, since removal of the surface layers of material is more effective in putting ions back into solution than the very slow process of ion exchange or desorption by non-corrosive methods.

b. Some of the more common decontamination procedures, involving both corrosive and non-corrosive methods, are given as follows:

1) Cleaning with an aqueous solution of a mild dishwashing detergent may suffice to remove most contamination and should be tried before attempting any of the harsher methods below that may potentially damage the item being cleaned.

2) All glassware should be washed with acid (chromic acid cleaning solution or concentrated nitric acid) and rinsed, as a routine procedure following use

(rinse thoroughly but avoid splashing). All metal tools employed should be surveyed to detect possible contamination.

3) The use of acid on metal tools may unnecessarily corrode them causing greater difficulty in future decontamination procedures. Some elements (i.e., iodine) will become volatile upon reaction with acids; in such cases it may be desirable to <u>attempt decontamination first with detergents</u>.

4) Equipment that is found to be contaminated after the initial treatment shall be stored in an isolated location, possibly in a hood with adequate exhaust, or underwater, until more thorough decontamination procedures may be applied. If it is necessary to dismantle any equipment prior to decontamination procedures, careful survey should be made during the operation. Contaminated equipment shall not be released from control of the laboratory for repair, or any other purpose, until the level of activity has been reduced to a safe limit. Where the half-life of the contaminating element is short, it may be desirable to store tools and glassware for decay of activity rather than to attempt decontamination of them. In many cases, if the items are cheap or easily replaced, it may be simpler to dispose of such equipment in a recommended manner and replace with new apparatus.

5) Equipment that is contaminated with long-lived isotopes and that cannot be satisfactorily decontaminated, must be regarded as radioactive waste and disposed of in a proper manner.

6) Glass and porcelain articles may be cleaned with mineral acids, ammonium citrate, trisodium phosphate, cleaning solution (chromic acid) or ammonium bifluoride. When the glaze is broken on porcelain, or when active solutions are heated to extreme dryness in glass, decontamination is very difficult, and usually it is more convenient to replace items so treated.

7) Metal objects may be decontaminated with dilute mineral acids (nitric), a 10 percent solution of sodium citrate, or ammonium bifluoride. When all other procedures fail for stainless steel, use hydrochloric acid. This is a good decontaminant, for the reason that it removes some of the surface; however, this procedure results in etching of the stainless steel, which makes it less desirable for future use. With brass, it has been demonstrated that brass polish is an excellent decontaminant. Plastics may be cleaned with ammonium citrate, dilute acids or organic solvents.

8) It should be noted that the effectiveness of a decontaminating process is, for all practical purposes, complete at the end of the second repetition of the process. If necessary, other methods should then be considered for further decontamination.

9) Laboratory equipment should be surveyed for residual contamination following decontamination procedures. Decontamination seldom exceeds 99.9 percent efficiency an usually is considerably less efficient. If the residual

contamination indicates that the level of activity is still greater than that specified as permissible equipment shall be regarded as radioactive waste. Glass equipment of this nature should be broken up to prevent accidental return to stock or other use.

10) Glassblowing, welding, brazing, soldering, etc., should never be permitted on equipment contaminated with radioactive materials unless it is done in special ventilated facilities, and special techniques are used to prevent the inhalation of radioactive dust and fumes.

5. Floors and Benches

a. Clean carefully as described below, using caution not to spread contamination.

b. First, try masking or adhesive tape to remove loose contaminants, <u>if material is dry</u>, or if wet, use absorbent material such as towels, "Kimwipes", disposable diapers, or toilet tissue. (Sanitary napkins can be useful because of their high absorbency and non-fragmenting characteristics.) The following steps can then be used:

1) If a wet mop will not remove the contamination, proceed with a method suitable for the particular surface material. Consult the Radiation Safety Officer before employing any of the following methods. Linoleum may be decontaminated by carbon tetrachloride, kerosene, ammonium citrate solution or dilute mineral acids; care should be take not to dissolve sealing compounds at the edges and between cracks of the linoleum. Ceramic tile may be decontaminated by the use of mineral acids, ammonium citrate or trisodium phosphate. Paint is sometimes successfully decontaminated by carbon tetrachloride or 10 percent hydrochloric acid; however, danger of dissolving the paint exists, and it is preferable to remove the paint and apply new coatings. With contaminated concrete no recourse is left except to remove the surface concrete with a chisel. Similarly, contaminated wood surfaces must be planed.

2) Detergents or wetting agents frequently may be used as successfully as harsher reagents for the decontamination of strippable plastics on polished stainless steel, glass or other smooth impervious laboratory surfaces. However, the combination of the contaminating conditions, the surface materials and the cleansing agent are interdependent variables that often influence the decontamination process.

3) Sinks, traps, and drains may sometimes be decontaminated by the following procedures:

a) Flush thoroughly with a large volume of water.

b) Scour with a rust remover and flush thoroughly.

c) Soak in a solution of citric acid prepared by adding 1 pound of acid to 1 gallon of water and flush thoroughly.

c. If contamination is not satisfactorily reduced after several attempts, it may be possible to tape or otherwise cover a surface and/or add shielding to reduce high exposure levels until the isotope has decayed or a practical removal method devised. Such covered areas of contamination should be appropriately labeled and adequately documented in facility survey records.

Appendix A: Glossary:

The following is a list of some of the terms and units that are basic for understanding and applying principles of radiation protection.

Alpha particles are equivalent in mass {4 atomic mass units (amu)} and charge (2 positive units) to helium nuclei. They are emitted primarily during decay of heavy nuclides including uranium, thorium, radium, and elements in the trans-uranium series. Alpha particles are emitted with discrete energies characteristic of the radionuclide. The energies for alpha particles emitted from typical nuclides are in the 3-6 MeV range. Alpha particles, because of their large mass, have a relatively low velocity. This velocity and the double positive charge mean that alpha particles interact strongly with matter, producing intense ionization as they dissipate their kinetic energy in very short distances. Alpha particles with an energy of 5 MeV will penetrate about 50 microns in tissue and produce 20-60,000 ion pairs per centimeter of air. In general, alpha particles can travel only short distances (3 inches) in air and can be stopped by a thin sheet of paper. When nuclides that emit alpha particles become deposited within a person's body, those cells within a fraction of a millimeter of the site of deposition will receive very large doses of radiation.

Beta particles which are emitted from the nucleus are identical to orbital electrons in mass (1/1840 amu) and charge (1 negative unit). As the result of the emission of a beta particle (negative), a neutron is converted to a proton in the nucleus so that the atomic number is increased by one. The atomic mass number remains the same. Beta particles are more penetrating than alpha particles. A beta particle will produce 50-200 ion pairs per centimeter of track length in air. Beta particles are emitted in a spectrum of energies; the average energy is 1/3 of the maximum.

Bremsstrahlung is electromagnetic radiation (like x-rays) produced when charged particles decelerate in matter. The production of bremsstrahlung depends directly upon the energy of the particle and the atomic number of the absorber. This means that large activity, high energy beta sources require shielding with sufficient thicknesses of low atomic number substances such as plastic (0.8 to 1.0 cm of plexiglass for ^{32}P).

Curie. The curie (abbreviated Ci) is the unit that describes the quantity of radioactivity, i.e., the number of nuclear transformations (or disintegrations) per unit time. One curie of activity equals 3.7×10^{10} nuclear transformations per second. The curie is a relatively large unit; most of the quantities of radioactivity used on campus are at the millicurie (mCi) or microcurie (µCi) level (i.e., 1/1,000th or 1/1,000,000th of a curie, respectively).

Electron volt is a small unit of energy useful to describing radiation energies of individual particles or rays. The sum of all the particle or ray energies absorbed by tissues accumulates to the macroscopic absorbed dose summarized in rad units. One electron volt equals 1.6×10^{-19} Joule and is the kinetic energy an electron would have after being accelerated through a potential difference of 1 volt. The maximum beta energies of ^{3}H, ^{14}C, and ^{32}P are respectively 18.6, 156, and 1700 keV.

Gamma rays and x-rays are part of the electromagnetic energy spectrum that also includes radio waves, visible light, and ultra-violet light, etc. X-Rays and gamma rays have very high energies, short wave lengths and readily penetrate matter. Gamma rays and x-rays differ only in their source. Gamma rays arise from the atomic nucleus while x-rays arise from orbital electron energy transitions.

Both of these radiations interact with matter mainly by transferring energy to orbital electrons of absorber atoms causing ionization. The ejected orbital electrons then decelerate, lose energy, in the same manner as beta particles. Because gamma rays and x-rays have no mass or electrical charge, the probabilities of interaction are small and the radiations are difficult to attenuate. Dense materials with high atomic numbers (i.e., lead, uranium, etc.) make the best shields against these radiations.

Half-life. The half-life of a radionuclide is the period of time required for half of the atoms in a sample of that nuclide to undergo nuclear transformation.

Half-value layer. The thickness of a specific shielding material required to attenuate 50% of the radiation of a given x-ray or gamma ray emitter. The half-value layer thickness depends on the density of the shielding and the energy of the emitter. For biological amounts of emitters, 10 half-value layers is often sufficient and can be checked using the table of gamma dose rate constants (Table 1). Unlike shielding for beta emitters, the number of half-value layers required may increase in proportional to the amount of gamma or x-ray emitter used.

Ionization is the process by which a neutral atom or molecule acquires a positive or negative electrical charge.

Linear energy transfer is the linear density at which energy is deposited along the track of a particle or ray, usually expressed in keV per micron. Particles such as protons, neutrons, and alpha particles have much higher rates of linear energy transfer than gamma rays, x-rays, or electrons and consequently do more biological damage and are assigned a higher quality factor for overall energy dose delivered to tissue.

Neutrons are electrically neutral particles with a mass of - 1 amu. They may be produced from nuclear interaction when high-energy particles interact with nuclei (especially when deuterium ions are accelerated) or by nuclear fission. Neutrons interact with matter in several ways: (1) being captured by nuclei, transmuting the nucleus to another isotope that can subsequently give off alpha, beta, and/or gamma radiations, or (2) by collision with nuclei, especially protons (hydrogen nuclei), transferring kinetic energy to the proton. The latter has an electrical charge and causes ionization as it dissipates its kinetic energy in matter. Such proton recoils are the most important dose considerations in the interaction of neutrons with tissue (which has many hydrogen atoms). Because of the large mass of the proton compared with the electron, the proton with the same kinetic energy will have a lower velocity and will lose its energy over a shorter unit length producing dense ionization along its track, similar to alpha particles. Neutron sources are frequently stored behind shields that contain large amounts of hydrogen atoms, such as water, paraffin, etc. Since neutrons also interact with nuclei and transmit stable nuclides into radioactive nuclides, special precautions may be required around sources where neutrons are being produced to protect against the induced radioactivity in the shielding, air, etc.

Positrons are positively charged beta particles (equivalent in mass to electrons). They are emitted from the nucleus in the same manner as negatively charged electrons. The process results in a proton being transformed to a neutron. The resulting nucleus will have one less positive charge and the same mass number as the original nucleus. Positrons are emitted in a spectrum of energies. When the positron collides with a negative electron both particles are annihilated. The masses of the positron and electron (each of which has a mass 1/1840 of an atomic mass unit) are totally converted to energy in accordance with formula, $E = mc^2$, two photons with energies of 0.511 MeV are produced. Since the annihilation radiations have the same characteristics as gamma rays, positrons sources require shielding like gamma sources.

Quality factor (QF) is a number by which absorbed doses are to be multiplied to obtain dose for radiation protection purposes. It is a quantity that expresses on a common scale the radiation harm incurred by exposed persons. It is elected based upon review of human and animal exposure data for various kinds of radiation. Quantitatively QF is related only to linear energy transfer of the radiation.

Rad is the unit of absorbed dose. One rad is the dose when any ionizing radiation deposits 100 ergs per gram in any material. Since one R of exposure in the energy range of 0.1 to 3 MeV dissipates 87 ergs per gram of air (or 96 ergs per gram in soft tissue), the units are said to be nominally equivalent.

Rem is the unit of dose equivalent that is used for radiation protection purposes. It is the product of the absorbed dose and a factor that relates it to the harmfulness to man. This latter factor is termed the Quality Factor. See Quality Factor above.

Roentgen, R, the unit of exposure, is the amount of x-ray or gamma radiation that will produce one esu of charge (approximately 2 billion electrical charges of either sign) per cc of air at standard temperature and pressure.

X-rays (see gamma rays).

APPENDIX B

PERSONNEL TRAINING PROGRAM

It may not be assumed that safety instruction has been adequately covered by prior training at other institutions, even experienced professionals will need instruction in your institution's procedures and the conditions of your license. Ancillary personnel (e.g., clerical, house-keeping, security) whose duties may require them to work in the vicinity of radioactive material (whether escorted or not) need to be informed about radiation hazards and appropriate precautions. A training program that provides necessary instruction should be written and implemented.

Personnel will be instructed:

1. Before assuming duties with, or in the vicinity of, radioactive materials.

2. During annual refresher training.

3. Whenever there is a significant change in duties, regulations, or the terms of the license.

Instruction for individuals in attendance will include the following subjects:

1. Applicable regulations and license conditions.

2. Areas where radioactive material is used or stored.

3. Potential hazards associated with radioactive materials in each area where the employees will work.

4. Appropriate radiation safety procedures.

5. Licensee's in-house work rules.

6. Each individual's obligation to report unsafe conditions to the Radiation Safety Officer.

7. Appropriate response to emergencies or unsafe conditions.

8. Worker's right to be informed of occupational radiation exposure and bioassay results.

9. Locations where the licensee has posted or made available notices, copies of pertinent regulations, and copies of pertinent licenses and license conditions (including applications and applicable correspondence) as required by Section 16.13, New York State Sanitary Code (10 NYCRR 16).

APPENDIX C

SUNY New Paltz
Radiation Safety Procedure and Training Review.

I____(print full name) certify that I have read and understood the SUNY New Paltz Radiation Safety Program and will follow said program. I also certify that I have been trained in the safe use of radioactive sources and equipment.

(Signature)_____________________________________ (Date) ______________________

Note to signer: maintain this certification with your permanent departmental records and send copy to the Campus Assistant Radiation Officer Laurence Rowe .