RADIOLOGICAL HAZARD ANALYSIS PROGRAM

Hazard analyses must be performed on all protocols involving the use of radioactive material. Each researcher must perform a written evaluation of experimental protocols for possible radiological hazards. The consequences of possible failures or errors must be considered. A means to mitigate any identified hazards must be provided. A copy of all documentation related to the hazard analyses must be maintained for access by laboratory personnel.

The Radiation Safety Officer will perform independent hazard analyses of all protocols submitted. The Radiation Safety Committee Chairman will review the hazard analysis of the protocols. After completion of the review process, recommendations will he made to the researcher. Once agreement has been achieved between the researcher, RSO and the RSC Chairman, the Radiation Safety Committee will review and provide final approval.

Protocols which are not equivalent to those already approved must have hazard analyses performed and be approved through normal channels before the desired changes are implemented. Amendments to Authorizations that request higher possession limits or new isotopes must include a hazard analysis.

The four major topics to be addressed in the hazard analysis are: training, facilities, radiological considerations and protocols. The actual training that will be provided to users is important to ensure that all workers have sufficient knowledge and experience to perform the radioisotope work in a safe manner. The submission of a detailed description of the facilities to be used, as well as all of the equipment, allows for a complete review of hazard potentials. Appropriate radiological considerations must be included in protocols to illustrate the methods which will be used to reduce hazards. The submission of detailed protocols will further improve the ability to recognize hazards.

Training of Users:

In addition to the formal Virginia Tech Radiation Safety Training, any lab specific training that users receive must be described. Training provided to allow for indirectly supervised work should include: observance of isotope use, dry runs of protocols, some directly supervised use, and usage under indirect supervision. Regular meetings with lab personnel to discuss procedures and procedural difficulties would be another useful training tool.

Facility Details:

Diagrams of all facilities to be used must be submitted. All equipment must be listed separately and specifically identified on the diagrams. An analysis of the hazards associated with each piece of equipment must be conducted. Refer to Attachment I for examples of hazard analyses.

Radiological Considerations:

The proper application of time, distance and shielding should be incorporated as needed to minimize personnel exposure. The use of shielding must be specifically addressed in the submittal. The selection of isotopes must be carefully considered to minimize personnel exposure. The minimum quantity of radioactivity should be used in protocols. Volatile products that contain radioactivity are expected to be trapped and/or vented in a fume hood. Dry runs must be used to evaluate hazards of new protocols.

Protocols:

All protocols involving radioactive material must be evaluated for hazards. Sufficient procedural detail must be provided to allow for an independent review of hazards by the Radiation Safety Officer, the Chairman of the Radiation Safety' Committee and the Radiation Safety Committee. Whenever hazards are recognized, procedures must incorporate a means to mitigate them. Special attention must be given to any production of aerosols, gases, volatile compounds or powders which contain radioactive material.

ANALYSIS PROGRAM FOOTNOTE

Radiological hazard analysis is an extensive and comprehensive process that will involve continual refinement as additional aspects are determined. Modifications will be made by the Radiation Safety Committee as necessary to improve the program.

ATTACHMENT I

Examples of Radiological Hazards Associated with
Various Equipment/Operations

Listing of Equipment and Operations

Centrifuges:

Aerosols are produced if tube breakage or leakage occurs. Aerosols can be produced if the braking process is too abrupt. Closed tubes and/or enclosed rotors should be used. At least one minute should be allowed for settling to occur. If leakage is apparent, a detailed contamination survey must be performed.

Denaturation of DNA:

DNA can be denatured by heat or chemical treatment. The use of heat has potential problems that are referenced in the “Heating” example. The addition of alkali should be considered as an alternate denaturation method. Even though alkali cannot be used for all applications, it is a quicker and safer technique.

Evaporation with a Nitrogen Stream:

This process can cause radioactive particles to be ejected from vessels by the gas stream. The lowest flow rate possible should be used. A plastic wrap or aluminum foil cover could be used to reduce the dispersal potential. This work must be performed inside of an operating fume hood.

Fume Hoods:

Spillage of fumes can occur if fume hoods are used with improper flow rates and if operations are conducted too close to the hood opening. A cluttered fume hood can also cause the spillage of fumes because of changes to the air flow pattern. The sash must be adjusted to the indicated level so that a proper flow rate of 100 - 150 EPM is achieved. Operations must be conducted at least 8 inches back from the sash. Individuals must not put their head inside of the fume hood during use.

Grinding Dry Material:

The grinding process can cause the dispersion of radioactive particles because of powder dispersal. Motorized grinders will normally cause more dispersal than manual devices unless they are totally enclosed. A draft-free area such as a glove box should be used for motorized equipment that is not completely sealed.

A manual technique that uses a mortar and pestle can disperse radioactive particles when used in conjunction with liquid nitrogen. A covering of aluminum foil or plastic wrap will reduce this potential.

The safest method for grinding material would involve the use of a wet rather than dry technique.

Heating:

Closed containers can pop open due to pressure build-up during the heating process. This can cause a violent discharge of the contents. the use of the lowest temperature necessary will create the least pressure build-up. Containment of pressure can be accomplished with various devices such as: screw cap containers, cap locks on snap-top containers or a pressure plate tube rack. Tube venting through a pin hole is a pressure relief mechanism that can cause radioactive vapors to be released through the hole. An aluminum foil cover will reduce this possibility. Venting of tubes should only be done inside of an operating fume hood.

When a water bath is used to heat containers, it can become contaminated if the container is externally contaminated or if the container leaks. Radioactive vapors could he evolved from the water bath by evaporation. A heat block equipped with sand or mineral oil as the conductive media is the best choice for heating tubes.

A rotary evaporation apparatus can cause radioactive vapors to be released if the trap fails. Redundant traps will provide a margin for error. This apparatus should be vented into an operating fume hood.

The use of a reflux condenser can cause radioactive vapors to be released if the cooling water or trap fails. Redundant traps will provide a margin for error. The apparatus should be vented into an operating fume hood.

Homogenizers:

A Polytron type homogenizer will generate aerosols during operation. More aerosols are produced when the blade nears the liquid surface. The safest use of this type of homogenizer would incorporate a shroud that encloses the top of the tube. This operation must be performed inside of an operating fume hood and the container must not be removed from the hood for at least one minute to allow for settling.

A Dounce type homogenizer generates aerosols at the beginning and end of each stroke unless extreme care is exercised. A plastic wrap cover could be used to reduce the release. This device should he used inside of an operating fume hood.

A Potter-Elvehjem type homogenizer generates aerosols similar to the Dounce type unless extreme care is exercised. An aluminum foil cover would be best suited to reduce the aerosol release since plastic wrap could become entangled with the moving shaft. This homogenizer should be used inside of an operating fume hood.

A finger twirl homogenization performed with a pellet pestle can generate aerosols unless extreme care is exercised. The pestle should be slowly put into the tube and remain submerged in liquid during use.

A french pressure cell (20,000 PSI) will cause aerosol generation as the last portion of liquid sample is drained from the bomb. The sample must be collected inside of an operating fume hood. The collection tubing and collection vessel must be secured during the draining process. The discharge area should be sealed with aluminum foil or plastic wrap.

A nitrogen cavitation bomb will cause aerosols to be produced when the rapid pressure release operation occurs. Valve leakage and back pressure contribute to the aerosol production. The discharge area should be secured and covered with aluminum foil or plastic wrap. The procedure should be performed inside of an operating fume hood.

A Mini-Bead Beater can cause containers to heat up during use dependent upon the time of shaking. This could jeopardize the integrity of the tubes. Care should be exercised to ensure that heat generation is not a concern.

Incubation:

Dependent upon incubation temperatures, sealed vessels can build up pressure. A pressure release will generate aerosols. Sealed containers should be carefully opened in an operating fume hood for venting purposes.

Water baths used for incubation can become contaminated if the container is externally contaminated or leakage occurs. The water bath can be protected from contamination by placing the primary container inside of a secondary container.

Iodinations (I-125):

The use of NaI (I-125) for protein iodinations causes the release of volatile radioiodine. A pH below 7 greatly accelerates the release of radioiodine. This process must be performed inside of an operating fume hood. Double gloves should be used when stock solutions are handled. Stock vials should be vented through a charcoal packed syringe prior to opening. The smallest activity stock vial that is necessary should be used, since this results in a lower release potential. Disposable columns must be capped and discarded as waste once they are used. If purification by dialysis is necessary, the beaker must be tightly covered whenever it is not in a fume hood, to avoid a release of radioiodine. Thyroid scans must be performed on individuals after each iodination.

Lyophilized Materials:

This fluffy material may be released during reconstitution when the vial is opened or solutions are added. The material must be reconstituted by addition of a solution through the rubber septum. This should be done inside of an operating fume hood.

Once the solution is added, a pressure build-up may occur during mixing. This would cause a release of material if the septum lifted from the vial. A syringe needle should be left in the septum during mixing to relieve any pressure build-up.

Methionine (S-35) Use:

The breakdown of methionine during the freeze/thaw and incubation processes will produce radioactive gases. Preparing aliquots of the stock solution upon arrival will reduce the quantity of breakdown products. The use of activated charcoal during the thawing process will absorb the volatiles. A syringe packed with charcoal should be used to vent the vial during the thawing process. This work must be performed inside of an operating fume hood or a laminar flow hood when sterile conditions are necessary. Activated charcoal should also be used during the incubation process. Physical forms such as charcoal impregnated filters or pelletized charcoal covered with cheesecloth are acceptable to absorb the volatiles. Finely powdered charcoal should not be used because of dispersal by air currents and/or static electricity.

Microtomes:

This equipment is routinely used to prepare ultra-thin sections of tissue that have been encased in an epoxy type material. Very small pieces can be dispersed by air currents during the slicing operation. Static electricity can also cause dispersion of these pieces. The operation must be performed in a draft-free area. The use of static eliminators should be considered.

Oxidizers:

The combustion process can generate airborne radioactivity if combustion begins before the vessel is inside of the burn chamber. The number of burns must be controlled if evidence of premature combustion is detected.

The excess carrier gas could release radioactive vapors if the trap fails. Traps should be vented directly into an operating fume hood.

It is preferable to locate the entire device inside of an operating fume hood.

Pipetters:

Aerosols are generated when Eppendorf-type pipetters are used. This causes the inside of the pipetter barrel to become contaminated. Pipette tips equipped with filters should be used for all radioactive applications.

If a pipetter is used for mixing operations, aerosols can be generated unless extreme care is exercised. Pipetters should only be used for stirring.

Purification of DNA:

Purification by ethanol precipitation requires lengthy hard spins of thermally shocked tubes, which are more likely to rupture. Extreme caution must be exercised after a spin is complete. The preferred method utilizes columns that are spun at slow speeds. Standard centrifugation precautions must be followed.

Repipetters:

Combination repipetters that are used to transfer radioactive solutions from a tube to a liquid scintillation vial followed with the addition of liquid scintillation fluid can cause aerosols to be generated unless extreme care is exercised. Greater aerosol potentials exist as the speed of additions increase. A shroud should be used to enclose the tube requiring additions so that aerosol releases are reduced. This work should be done in an operating fume hood.

Sealed Sources:

Electron capture detectors (ECD) are used for analysis in gas chromatography equipment. The detector contains a radioactive source that can be damaged by excessive oven temperatures. The foil can melt and cause a release of radioactive particles in the carrier gas stream. Oven controls must be present that will prevent the manufacturer's specified temperature from being exceeded. Normally, a fusible link is the protection designed into the equipment by the manufacturer.

Improper ECD cleaning techniques can leach radioactive material from the foil. ECD's must not be cleaned by' University personnel. Outside companies can perform this function as needed.

All exhausts for ECD's should be vented to an operating fume hood.

Moisture/density gauges are used as either permanently installed devices or portable devices. The potential problems for permanently installed devices are uncontrolled access to the source and damage to the source housing. Strict key control to the room and/or source shutter will reduce potential exposure to individuals. The possibility of damage due to crushing or melting is limited by locating the device in an area where physical hazards are unlikely.

Portable gauges can be damaged during transport or stolen while at the test site. One other principal hazard involves the source becoming stuck outside of the protective housing. Transportation problems are mitigated by ensuring that gauges are secure while in transit and the proper shipping documents are present in the event of a vehicle accident. The gauge must be protected from theft by being locked up whenever the authorized user is not physically present. The prevention of stuck radioactive source probes is accomplished by always using a dummy probe to ensure insertion holes are of the appropriate size before the actual source probe is inserted.

Other sealed sources are used as reference sources or to test/study equipment. Source shielding and integrity are the most important considerations. If the radioisotope can pose an external radiation hazard, unshielded use must be avoided. Source integrity must be protected by using appropriate handling techniques. The active portion of sources must never be touched.

Shielding Use:

Some isotopes pose external radiation hazards which can be controlled by the appropriate use of shielding.

P-32 should be shielded with low density materials to avoid the secondary production of x-rays (bremsstralung). The materials of choice are: plexiglass, glass, water or aluminum. Eye protection must be worn to shield the lens of the eye. A plexiglass bench-top shield should be used for the majority of manipulations with high activities. Tubes should be shielded with tygon tubing holders, plexiglass blocks or aluminum blocks while in storage or in use. Waste receptacles should be shielded with plexiglass or aluminum.

I-125 should be shielded with lead foil to attenuate the x and gamma rays. A bench-top shield composed of lead acrylic, lead glass or lead should be used for the majority of manipulations with high activities. Working solutions in storage should be shielded with lead foil as necessary. Waste receptacles should be shielded with lead foil or galvanized steel as necessary.

Isotopes such as Cr-5I and Zn-65 require considerable lead shielding and must be addressed on an individual basis. Generally, a leaded bench-top shield will protect the body during manipulations with high activities, had bricks and/or lead sheets will be necessary to shield waste receptacles. Working solutions in storage can be shielded with lead containers.

Sonicators:

The sonication process generates aerosols. The use of long tubes as vessels reduces the magnitude of aerosol release. Parafilm, plastic wrap or aluminum foil used as a seal between the vessel and the probe can reduce the release of aerosols. The most effective method to prevent aerosol releases utilizes a rubber aerosol cap that seals the container to the probe shaft. This process must be done inside of an operating fume hood. The container must not be removed from the hood for at least one minute to allow for settling.

TLC Plates:

The silica gel that is scraped from plates can be dispersed easily because of its powdery condition. Plate scraping must be performed in a draft-free area while the individual wears a dust mask. If plates can be moistened before scraping, dispersal is less likely. The use of aluminum-backed or plastic-backed silica gel plates is preferable since plate scraping would not usually be required.

Powder can be dispersed when liquid scintillation fluid is added to a vial. The silica gel should be put into the vials after scintillation fluid is added.

The safest analysis technique involves the use of a TLC plate reader. This instrument allows for nondestructive analysis of the plates and avoids the plate scraping activity.

Vacuum Systems:

The discharge of vacuum pumps may contain radioactivity. Vacuum pumps should be exhausted through a filter. In-line filters and/or traps could also be used.

House vacuum lines may remove radioactivity. These systems should only be used if no other alternatives exist. In-line traps and/or filters must be used to protect the house vacuum system.

Vortexers:

Aerosols are produced during the vortexing process. The use of capped or covered tubes will prevent aerosols from being released. At least one minute should be allowed for aerosols to settle prior to opening the container.

Weighing Powders:

Air currents can cause powders to disperse. Static electricity can also cause the dispersal of powders. This process must be performed in a draft-free area and a static eliminator should be used.