NRC Guidelines for the Radiation Safety Officer
ALARA

ALARA is an acronym for an important principle in radiation protection and stands for "As Low As Reasonably Achievable". The aim is to minimize the risk of radioactive exposure or amount of dose while keeping in mind that some exposure may be acceptable in order to further the task at hand.

In radiology, the application of radiation can aid the patient by providing doctors with a medical diagnosis, but the exposure should be reasonably low enough to keep the statistical probability of cancers or sarcomas (stochastic effects) below an acceptable level, and to eliminate deterministic effects (e.g. skin reddening or cataracts). An acceptable level of incidence of stochastic effects is considered to be equal for a worker to the risk in another work generally considered to be safe.

This policy is based on the principle that any amount of radiation exposure, no matter how small, can increase the chance of negative biological effects such as cancer, though perhaps by a negligible amount. It is also based on the principle that the probability of the occurrence of negative effects of radiation exposure increases with cumulative lifetime dose. These ideas are combined to form the linear no-threshold formula. At the same time, radiology and other practices that involve use of radiation bring benefits to population, so reducing radiation exposure can reduce the efficacy of a medical practice. The economic cost, for example, of adding a barrier against radiation must also be considered when applying the ALARA principle.

There are four major ways to reduce radiation exposure to workers or to population:

- **Shielding.** Use proper barriers to block or reduce ionizing radiation.
- **Time.** Spend less time in radiation fields.
- **Distance.** Increase distance between radioactive sources and workers or population.
- **Amount.** Reduce the quantity of radioactive material for a practice.
PROGRAM FOR MINIMIZING OCCUPATIONAL RADIATION EXPOSURES-

Management commitment:

We, the management, are committed to the program described in this section for keeping exposures (individual and collective) as low as is reasonably achievable (ALARA). In accord with this commitment, we hereby describe an administrative organization for radiation safety and will develop the necessary written policy, procedures, and instructions to foster the ALARA concept within our institution. The organization will include a Radiation Safety Committee and a Radiation Safety Officer (RSO).

We will perform a formal annual review of the radiation safety program, including ALARA considerations. This shall include reviews of operating procedures and past exposure records, inspections, etc., and consultations with the radiation protection staff or outside consultants.

Modification to operating and maintenance procedures and to equipment and facilities will be made where they will reduce exposures unless the cost, in our judgment, is considered to be unjustified. We will be able to demonstrate, if necessary, that improvements have been sought, that modifications have been considered, and that they have been implemented where reasonable. Where modifications have been recommended, but not implemented, we will be prepared to describe the reasons for not implementing them.

In addition to maintaining doses to individuals as far below the limits as is reasonably achievable, the sum of the doses received by all exposed individuals will also be maintained at the lowest practical level. It would not be desirable, for example, to hold the highest doses to individuals to some fraction of the applicable limit if this involved exposing additional people and significantly increasing the sum of radiation doses received by all individuals.

Radiation Safety Committee - review of proposed users and uses:

The Radiation Safety Committee will thoroughly review the qualifications of each applicant with respect to the types and quantities of materials and uses for which the applicant has applied to ensure that the applicant will be able to take appropriate measures to maintain exposure ALARA.

When considering a new use of radioactive material, the Radiation Safety Committee will review the efforts of the applicant to maintain exposure ALARA. The user should have systematized the procedures to ensure ALARA and shall have incorporated the use of special equipment such as syringe shields, rubber gloves, etc., in his/her proposed use.

The Radiation Safety Committee will ensure that the user justifies his/her procedures and that doses will be ALARA (individual and collective).
Delegation of authority (The judicious delegation of Radiation Safety Committee authority is essential to the enforcement of an ALARA program):
The Radiation Safety Committee will delegate authority to the RSO for enforcement of the ALARA concept.
The Radiation Safety Committee will support the RSO in those instances where it is necessary for the RSO to assert his/her authority. Where the RSO has been overruled, the Committee will record the basis for its action in the minutes of the Committee's semi-annual meeting.

Review of ALARA program:
The Radiation Safety Committee will encourage all users to review current procedures and develop new procedures as appropriate to implement the ALARA concept.
The Radiation Safety Committee will perform a semi-annual review of occupational radiation exposure with particular attention to instances where Investigational Levels in Table 1 below are exceeded. The principal purpose of this review is to assess trends in occupational exposure as an index of the ALARA program quality and to decide if action is warranted when Investigational Levels are exceeded.
The Radiation Safety Committee will evaluate the institution's overall efforts for maintaining exposures ALARA on an annual basis. This review will include the efforts of the RSO, authorized users, and workers as well as those of management.

- Radiation Safety Officer (RSO) duties:
  1. Annual and semi-annual review:
     A. Annual review of the radiation safety program. The RSO will perform an annual review of the radiation safety program for adherence to ALARA concepts. Review of specific procedures may be conducted on a more frequent basis.
     B. Semi-annual review of occupational exposures. The RSO will review at least every six months external radiation exposures of authorized users and workers to determine that the exposures are ALARA.
     C. Semi-annual review of records of radiation level surveys. The RSO will review radiation levels in unrestricted and restricted areas to determine that they were at ALARA levels during the previous six months.
  2. Education responsibilities for ALARA program:
     A. The RSO will schedule briefings and educational sessions as needed to inform workers of ALARA program efforts.
     B. The RSO will ensure that authorized users, works, and ancillary personnel who may be exposed to radiation will be instructed in the ALARA philosophy and informed that the management, the Radiation
Safety Committee, and the RSO are committed to implementing the ALARA concept.

3. Cooperative efforts for development of ALARA procedures:
   A. Radiation workers will be given opportunities to participate in formulation of the procedures that they will be required to follow.
   B. The RSO will be in close contact with all users and workers in order to develop ALARA procedures for working with radioactive materials.
   C. The RSO will establish procedures for receiving and evaluation the suggestions of individual workers for improving health physics practices and will encourage the use of those procedures.

4. Reviewing instances of deviation from good ALARA practices:
   A. The RSO will investigate all known instances of deviation from good ALARA practices and, if possible, will determine the causes. When the cause is known, the RSO will require changes in the program to maintain exposures ALARA.

- Authorized users:
  1. New procedures involving potential radiation exposures:
     A. The authorized user will consult with, and receive the approval of, the RSO during the planning stage before using radioactive material for a new procedure.
     B. The authorized user will evaluate all procedures before using radioactive materials to ensure that exposures will be kept ALARA. This may be enhanced through the application of trial runs.
  2. Responsibilities of authorized user to persons under his/her supervision:
     A. The authorized user will explain the ALARA concept to his/her commitment to maintain exposures ALARA to all persons under his/her supervision.
     B. The authorized user will ensure that persons under his/her supervision who are subject to occupational radiation exposure are trained and educated in good health physics practices and in maintained exposure ALARA.

- Persons who receive occupational radiation exposure:
  1. The worker will be instructed in the ALARA concept and its relationship to working procedures and work conditions.
  2. The worker will know what resources are available if he/she feels that ALARA is not being promoted on the job.

- Establishment of investigational levels in order to monitor individual occupational external radiation exposures:
  1. This institution hereby establishes Investigational Levels for occupational external radiation exposure who, when exceeded, will initiate review or investigation by the RSO. The Investigational Levels that we have adopted
are listed in Table 1 below. These levels apply to the exposure of individual workers.

Table 1. Investigational levels (mrems per calendar quarter)

<table>
<thead>
<tr>
<th>Organs</th>
<th>Level I</th>
<th>Level II</th>
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<tr>
<td>Whole body (total effective dose equivalent)</td>
<td>125</td>
<td>375</td>
</tr>
<tr>
<td>Individual organs - except lens</td>
<td>1,250</td>
<td>3,750</td>
</tr>
<tr>
<td>(sum of deep dose equivalent and committed dose equivalent)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lens of eye</td>
<td>375</td>
<td>1,125</td>
</tr>
<tr>
<td>Skin or extremity</td>
<td>1,250</td>
<td>3,750</td>
</tr>
</tbody>
</table>

- The Radiation Safety Officer will review and record on form NRC-5 "Occupational Exposure Record for a Monitoring Period", or an equivalent form (e.g., dosimeter processor’s report), results of personnel monitoring not less than once in any calendar quarter as required by section 20.2102 or 10 CFR Part 20. The following actions will be taken at the Investigational Levels as stated in Table 1:

1. Personal dose to less than Investigational Level I:
   Except when deemed appropriate by the RSO, no further action will be taken in those cases where an individual’s exposure is less than Table 1 values for Investigational Level I.

2. Personal dose equal to or greater than Investigational Level I, but less than Investigational Level II:
   A. The RSO will review the exposure of each individual whose quarterly exposures equal or exceed Investigational Level I and will report the results of the reviews at the first Radiation Safety Committee meeting to follow when the exposure was recorded. If the exposure does not equal or exceed Investigational Level II, no action related specifically to the exposure is required unless deemed appropriate by the Radiation Safety Officer. The RSO, will, however, consider each such exposure in comparison with those of others performing similar tasks as an index of ALARA program quality and will record the review in the Committee minutes.

3. Personal dose equal to or greater than Investigational Level II:
   A. The RSO will investigate in a timely manner the cause(s) of all personnel exposures equaling or exceeding Investigational Level II and,
if warranted, will take action. A report of the investigation, actions taken, if any, and a copy of the individual's Form NRC-5 or its equivalent will be presented to the RSO at the Radiation Safety Committee meeting following completion of the investigation. The details of these reports will be recorded in the Radiation Safety Committee minutes. Committee minutes will be sent to the management of this institution for review. The minutes, containing details of the investigation, will be made available to NRS/state inspectors for review at the time of the next inspection.

4. Reestablishment of an individual occupational worker’s Investigational Level to a level above that listed in Table 1:
   A. In cases where a worker's or a group of workers' exposure need to exceed an Investigational Level, a new, higher Investigational Level may be established on the basis that it is consistent with good ALARA practices for that individual or group. Justification for new Investigational Levels will be documented.
PERSONAL EXTERNAL MONITORING PROGRAM

- The Radiation Safety Officer (RSO) will promptly review all exposure reports to look for workers or groups of workers whose exposure is unexpectedly high or low.
- All individuals who are occupationally exposed to ionizing radiation on a regular basis will be issued a whole body monitor that will be processed on a monthly basis.
- All individuals who, on a regular basis, handle radioactive material that emits ionizing radiations will be issued a finger monitor that will be processed on a monthly basis.
- Other individuals who are exposed to radiation on an occasional basis such as security personnel who deliver packages, secretarial personnel who work in the nuclear medicine clinic, but do not work with patients, and nurses who occasionally care for patients who have received diagnostic dosages will not normally be issued exposure monitors.
- Personnel dosimeters that require processing to determine the dose to compare to the Colorado Part 4, 4.6 limits will be processed and evaluated by: Laundauer Inc.
  2 Science Road
  Glenwood, IL 60425
  A dosimetry processor that is accredited under the National Volunteer Laboratory Accreditation Program (NVLAP) (10 CFR 20.1501)
PROCEDURES FOR ORDERING AND RECEIVING RADIOACTIVE MATERIAL

The RSO or a designee must authorize each order for radioactive materials and ensure that the requested materials and quantities are authorized by the license for use by the requesting authorized user and that possession limits are not exceeded.

The RSO will establish and maintain a system for ordering and receiving radioactive material. The system must contain the following information:

1. For routinely used materials:
   A. Written records will be made that identify the authorized user or department, isotope, chemical formation, activity, and supplier.
   B. The above records will be checked to confirm that the material received was ordered through proper channels.

2. For occasionally used material (e.g. therapeutic dosages):
   A. The authorized user who will perform the procedure will make a written request that indicates the isotope, radiopharmaceutical, activity, and supplier.
   B. The person who receives the material will check the physician's written request to confirm that the material received is what was ordered.

- For deliveries during normal working hours, the RSO will tell carriers to deliver radioactive packages directly to the Nuclear Medicine laboratory.
PROCEDURES FOR SAFELY OPENING PACKAGES CONTAINING RADIOACTIVE MATERIAL

The external surfaces of any package know to contain radioactive material shall be monitored for radioactive contamination and radiation levels if the package is labeled as containing radioactive material or has evidence of potential contamination, such as packages that are crushed, wet, or damaged.

1. All packages must be monitored and wipe tested as soon as practicable after receipt of the package, but not later than 3 hours after the package is received at the facility if it is received during normal working hours.
2. The State Health Department and the final delivery carrier shall be notified immediately by telephone and telegram, mail, or fax if the removable radioactive surface contamination exceeds 0.001 uCi (2,200 dpm) per 100 square cm (for beta and gamma emitting radionuclides) of if the external radiation levels exceed 200 mrem/hour at any point on the external surface.

- For packages received under the specific license, the following procedure for opening each package will be followed:
  1. Put on gloves to prevent hand contamination.
  2. Visually inspect the package for any sign of damage (e.g., wet or crushed). If damage is noted, stop the procedure and notify Radiation Safety Officer (RSO).
  3. Measure the exposure rate from the package at 1 meter and at the package surface. If it is higher than expected, stop and notify the RSO. (The "transport index" noted on the package with "Yellow II" or "Yellow III" labels is the approximate dose rate, in millirems per hour, at 1 meter from the package surface; the surface dose rate for Yellow III packages should not exceed 200 millirems per hour. The dose rate from packages with "White I" labels should be less than 0.5 millirems per hour at the package surface.
  4. Open the package with the following precautionary steps:
     A. Remove the packing slip.
     B. Open the outer package following the supplier's instructions, if provided.
     C. Open the inner package and verify that the contents agree with the packing slip.
     D. Check the integrity of the final source container. Look for broken seals or vials, loss of liquid, condensation, or discoloration of packing material. If anything is other than expected, stop and notify the RSO.
  5. For all packages, wipe the external surface of the final source container and remove the wipe sample to a low-background area. Assay the wipe sample to determine if there is any removable radioactivity. The well counter will be used to assay wipes. The detection efficiency must be determined to
convert wipe sample counts per minute to disintegration per minute. Note that a dose calibrator is not sufficiently sensitive for this measurement. Take precautions against the potential spread of contamination.

6. Check the user request to ensure that the material received is the material that was ordered.

7. Monitor the packing material and the empty packages for contamination with a radiation detection survey meter before discarding.
   A. If contaminated, treat this material as radioactive waste.
   B. If not contaminated, remove or obliterate the radiation labels before discarding in-house trash.

8. Make a record of the receipt.
RECORDS OF RADIOACTIVE MATERIAL USE

- Unit dose use - for each unit dose received from a supplied, make a record in the patient log of the following (for information regarding proper labeling of the unit dose syringe, see Section 23-1):
  - Radionuclide.
  - Generate name or its abbreviation or trade name.
  - Date of receipt.
  - Supplier.
  - Lot number or control number, if assigned.
  - Activity in uCi or mCi as recorded on the unit dosage or packing and its associated time.
  - Date of administration or disposal.
  - If administered:
    - Prescribed dosage (unless already recorded in clinical procedure manual).
    - Measured activity in uCi or mCi and date and time of measurement.
    - If discarded, the date and method of disposal.
  - Initials of the individual who made the record.
RULES FOR THE SAFE USE OF RADIOPHARMACEUTICALS

- Wear laboratory coats or other protective clothing at all times in areas where radioactive materials are used.
- Wear disposable gloves at all times while handling radioactive materials.
- Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.
- Do not store food, drink, or personal effects in areas where radioactive material is stored or used.
- Wear personnel monitoring devices at all times while in areas where radioactive materials are used or stored. These devices should be worn as prescribed by the Radiation Safety Officer. When not being worn to monitor occupational exposures, personnel monitoring devices should be stored in work place in a designated low-background area.
- Wear a finger exposure monitor during the injection of radiopharmaceuticals; and when holding patients during procedures.
- Dispose of radioactive waste only in designated, labeled, and properly shielded receptacles.
- Wipe-test weekly for contamination. If necessary, decontaminate or secure the area for decay.
- With a radiation detection survey meter, survey for contamination. If necessary, decontaminate or secure the area for decay as appropriate.
- Syringes and unit dosages should be labeled with the radiopharmaceutical name or abbreviation, type of study, or the patient’s name. Assay each patient’s dose in the dose calibrator before administered it. Do not use a dosage if it is more than 10% off from the prescribed dosage, except for prescribed dosages of less than 10 uCi. When measuring the dosage, you need not consider the radioactivity that adheres to the syringe wall or remains in the needle. Check the patient’s name and identification number and the prescribed radionuclide, chemical form, and dosage before administering.
AREA SURVEY PROCEDURES

- **Ambient dose rate surveys:**
  1. Survey areas:
     A. In radiopharmaceutical preparation and administration areas, survey these areas at the end of each day of use with a survey meter.
     B. In laboratory areas where only small quantities of the gamma-emitting radioactive material are processed (less than 200 uCi at a time), survey monthly with a radiation detection survey meter.
     C. In radiopharmaceutical storage areas, survey daily with a radiation detection survey meter.
     D. In sealed source and storage areas, survey daily with a radiation measurement survey meter.
  2. Record the ambient dose rate results in the Area Radiation Survey Report (prepared in Unit Dose Manager Program).
  3. Immediately notify the RSO if unexpectedly high or low levels are found.

- **Removable contamination surveys (wipe tests) will be performed weekly.**
  1. Survey areas:
     In radiopharmaceutical preparation and administration areas, survey weekly for removable contamination.
     In laboratory areas where only small quantities of gamma-emitting radioactive material are processed (less than 200 uCi at a time), survey weekly for removable contamination.
     In radiopharmaceutical storage and radiopharmaceutical waste storage areas, survey weekly for removable contamination.
  1. The wipe sample assay procedure should be sufficiently sensitive to detect the presence of 2,000 dpm/100 cm squared or removable contamination. A radioactive source with a known amount of activity is used to convert sample measurements (usually in counts per minute or cpm) to disintegration per minute.

\[
dpm = cpm \times E
\]

Where: \(dpm = \) disintegration per minute
\(cpm = \) counts per minute (background corrected)
\(E = \) counting efficiency of counting equipment

  2. Record the ambient dose rate results in the Area Wipe Test Report (see below).
  3. Immediately notify the RSO if unexpectedly high levels are found.
  4. All incoming and returning shipments of radioactive materials will be surveyed and wipe testing as described above.
Records: (In Unit Dose Manager Program)
Keep a record of dose rate and contamination survey results. It must include
the following information:
The date, area surveyed, and equipment used.
The name or initials of the person who made the survey.
A drawing of the areas surveyed with contamination and dose rate action
levels as established by the RSO. (Recommended removable surface
contamination action levels are published in Regulatory Guide S.23,
"Radiation Safety Surveys at Medical Institutions").
Measured dose rates in mR/hr or contamination levels in dpm/100 cm
squared as appropriate.
Actions taken in the case of excessive dose rates or contamination and
follow-up survey information.
The RSO will review and initial the record promptly in those cases in which
action levels are exceeded.
RADIOACTIVE SPILL PROCEDURES

- Minor spills of liquids and solids:
  Notify persons in the area that has a spill has occurred.
  Prevent the spread of contaminations by covering the spill with absorbent paper.
  Clean up the spill using disposable gloves and absorbent paper. Carefully fold the absorbent paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Also, put contaminated gloves and other contaminated disposable material in the bag.
  Survey the area with a low-range radiation detector survey meter. Check the area around the spill. Also, check your hands, clothing, and shoes for contaminations.
  Report the incident to the RSO.
  The RSO will follow-up on this clean up of the spill and will complete the Radioactive Spill Report and the Radioactive Contamination Survey (see below).

- Major spills of liquids and solids:
  Clear the area. Notify all persons not involved in the spill to vacate the room.
  Prevent the spread of contamination by covering the spill with absorbent paper, but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all personnel who may be contaminated.
  Shield the source if possible. This should be done only if it can be done without further contamination or a significant increase in radiation exposure.
  Close the room and lock or otherwise secure the area to prevent entry.
  Notify the RSO immediately.
  Decontaminate personnel by removing the contaminated clothing and flushing contaminated skin with lukewarm water and then washing with mild soap. If contamination remains, induce perspiration by covering the area with plastic. Then wash the affected area again to remove any contamination that was released by perspiration.
  The RSO will supervise the clean up of the spill and will complete the Radioactive Spill Report and Radioactive Spill Contamination Survey (see below).
PROCEDURE FOR WASTE DISPOSAL

All radioactivity labels must be defaced or removed from containers and packages prior to disposal in in-house waste. If waste if compacted, all labels that are visible in the compacted mass must be defaced or removed. Remind employees that non-radioactive waste such as boxes and packing material should not be mixed with radioactive waste.

Procedure for disposable by Decay-by-Storage (DIS):
Short-lived material (physical half-life less than 65 days) may be disposed of by DIS. Keep material separate according to half-life. Because the waste will be surveyed with all shielding removed, the containers in which waste will be disposed of must not provide any radiation shielding for material. When the container is full, seal it with string or tape and attach an identification tag that includes the date sealed, the longest-lived radioisotope in the container, and the initials of the person sealing the container. The container may then be transferred to the DIS area. Decay the radioactive material for at least 10 half-lives of the longest-lived radioisotope.

Prior to disposal as in-house biohazardous waste, monitor each container as follow. Record the results in the Radioactive Waste Disposal Record (see below):
- Check to insure proper operation of your radiation detection survey meter.
- Plain to monitor in a low-level (less than 0.05 millirems per hour) area.
- Remove any shielding from around the container.
- Monitor all surfaces of each individual container.
- Discard as biohazardous waste only those containers that cannot be distinguished from background. Record the date on which the container was sealed, the disposal date, and type of material (e.g., paraphernalia, unused dosages). Check to be sure no radiation labels are visible.
- Containers that can be distinguished from background radiation levels must be returned to the storage area for further decay.
WORKING WITH XENON-133

Xenon-133 is usually administered by a rebreather unit. These generally allow the disposal of expired xenon by one of two methods.

The simplest way is to exhaust the xenon to the atmosphere, remembering that the US Nuclear Regulatory Commission requires the average yearly concentration of xenon emission to be less than $5 \times 10^{-7} \, \mu \text{Ci} / \text{mL}$. The exhaust vent should be placed near the floor because xenon is heavier than air.

A more common method is to use an activated charcoal trap to accumulate the exhaled xenon gas until it has decayed to background.

Regardless of equipment and methodology used, $^{133}\text{Xe}$ imaging should be performed in a room with negative pressure in case of accidental leakage from the closed system, especially during administration to the patient.
REFERENCES

Department of Public Health and Environment Part 4, Standards for Protection Against Radiation.
Department of Public Health and Environment Part 7, Use of Radionuclides in the Healing Arts.
RADIOACTIVE SPILL REPORT

Institution ____________________________________________________

Time of spill __________ am/pm  Date ________________  Room ___________

Give a brief description of the incident:
___________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

Radioisotope present or suspected in the spill:
______ mCi of ______ as _______________________
______ mCi of ______ as _______________________
______ mCi of ______ as _______________________

Instrument used to check personnel in the spill:

Meter model ______________  Serial number ______________

Probe model ______________  Serial number ______________

Personnel present  Personnel contamination survey results
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

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Radioactive Spill Contamination Survey

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-clean mR/hr</th>
<th>Post-clean mR/hr</th>
<th>dpm/100 cm squared</th>
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Give brief description of follow-up actions taken to prevent recurrence:

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

Technologist/Physicist: ______________________________