C. ALARA/Time, Distance, Shielding

NCI-Frederick fully supports the concept that all radiation doses should be as low as reasonable achievable, or ALARA, for all employees, visitors, and students. This implies that no dose should be acceptable if it can be avoided. NCI-Frederick's ALARA program depends on the cooperation of all authorized radiation users, as well as their supervisors and PIs.

One can maintain exposures ALARA by practicing the following basic principles of radiation protection:

1. External Radiation Protection:

a. **Minimize time of exposure**. The shorter the time you spend in a radiation field, the lower the dose your body absorbs. Perform the experiment or the procedures as quickly as possible without increasing the probability of an accident or spill.

b. **Maximize the distance from the source**. For all types of radioactive materials, increasing the distance from the source of radiation will decrease the potential hazard and level of the dose received.

i. Beta rays of a given energy level have a finite range in air. The range of beta particles in air is approximately 12 ft/Mev. The chart below list maximum particle range for some common isotopes used at NCI-Frederick:

Isotope	Maximum Energy in Mev	Maximum Range
3H	0.0186	<3 in.
C-14	0.156	22 in.
S-35	0.168	2 ft.
P-32	1.71	20 ft.

ii. Gamma and X-rays follow the inverse square law. For example, doubling the distance from a radiation source will result in one-fourth the exposure in the same amount of time. One practical implementation of this principle is using remote handling devices such as forceps, tongs, tube racks, etc., to minimize direct contact with large sources of gamma-emitting material.

c. **Shield the radiation source properly**. Proper shielding will reduce almost all radiation emissions in the common laboratory setting.

i. For low-energy beta emitters (H-3, 14-C, 33-P, and S-35): Shielding is not normally required because their emissions are too weak to penetrate clothing or the surface layer of

the skin. However, common safety practices include using absorbent paper, carefully closing all containers, etc.

ii. For high-energy beta emitters (P-32): P-32 is most effectively shielded with 3/8-inch thick Plexiglas shields. Lead is not to be used with this isotope because of the potential generation of bremsstrahlung X-rays.

iii. For gamma and X-rays (Cr-51 and I-125): Low-energy chromium and iodine can be shielded with 3/8-inch Plexiglas, whereas higher concentrations may require thin lead foil that can be manipulated to cover the containers.

2. Internal Exposure Protection

a. Inhalation: A chemical fume hood or biological cabinet that has been certified for radioactive materials work is highly recommended when using potentially volatile compounds. Use centrifuges, vortex mixers, shakers, etc., in such a way that production of and exposure to radioactive aerosols is minimized.

b. Puncture: Dispose of syringes and pipettes promptly and in appropriate containers. Do not attempt to recap needles after use. Guard against glass breakage and puncture injury during use and disposal.

c. Ingestion: Never introduce any food or drink into a posted radiation area.

d. Absorption: Use measures to prevent contamination of skin and eyes such as lab coat, gloves, and eye protection. Eye protection is especially important if you wear contact lenses, since some lenses will absorb and concentrate radioactive materials. Wash hands after manipulating radioactive materials, and monitor hands for contamination, especially before eating or smoking, and prior to leaving the radiation area.