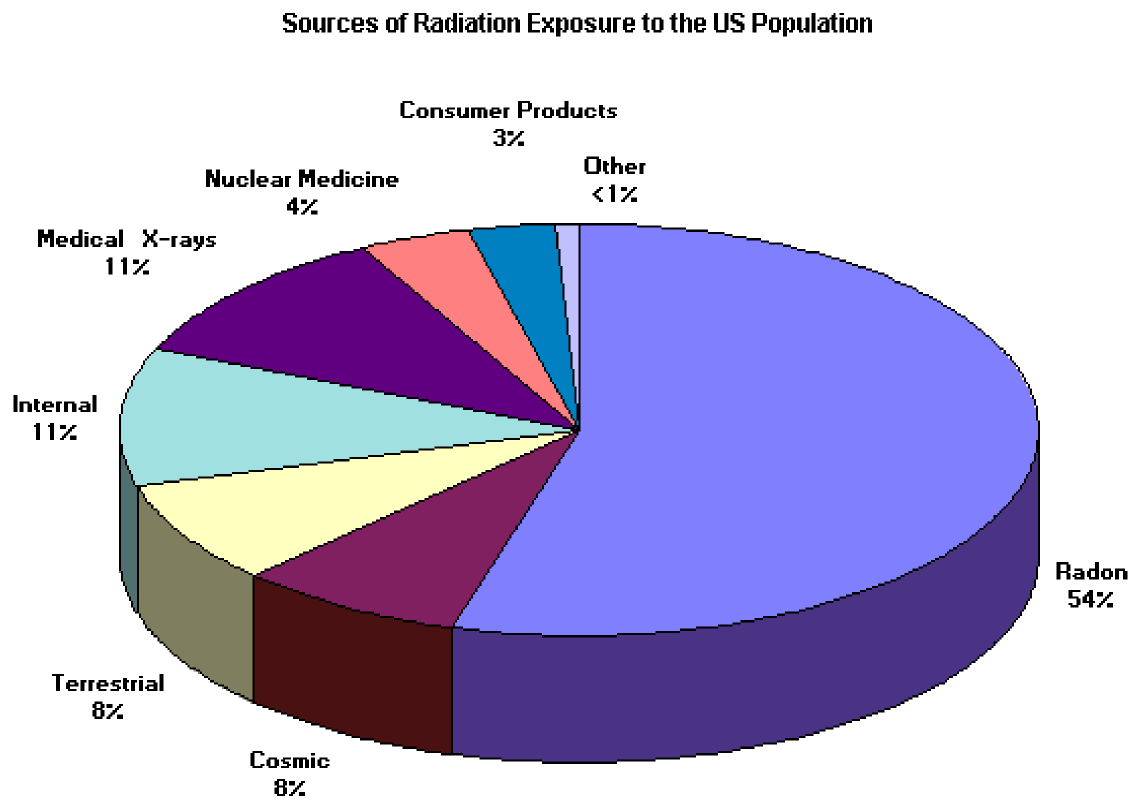
Radiation is all around us



Webster's dictionary defines risk as "the chance of injury, damage, or loss; a dangerous chance, a hazard". The chances of incurring risk can often be quantified and is usually shown as a probability of an event resulting from an action or activity. The field of risk management seeks to minimize risk to personnel who are often engaged in multiple activities with several sources of risk. Virtually all activities carry with them some sort of risk, even common activities such as driving, swimming or smoking cigarettes.

There are two ways to quantify risk:

1. A probability of death from an activity. A risk of 10^{-3} means that one individual in 1,000 will die from exposure to that activity.

2. A loss of life expectancy. A risk that results in a loss of life expectancy of 30 days means that, over an average life-span, an average person will die 30 days sooner from exposure to that risk than if they never encountered it.

Loss of Life Expectancy

Health Risk	Estimated Life Expectancy Lost
Smoking 20 cigarettes per day	6 years
Overweight (15%)	2 years
Alcohol (US Average)	1 year
All Accidents	207 days
All Natural Hazards	7 days
Occupational dose (300 mrem/year)	15 days
Occupational dose (1 rem/year)	51 days

Loss of Life Expectancy on the Job

Industry Type	Estimated Life Expectancy Loss
All Industries	60 days
Agriculture	320 days
Construction	227 days
Mining and quarrying	167 days
Manufacturing	40 days
Occupational dose (300 mrem/year)	15 days
Occupational dose (1 rem/year)	51 days

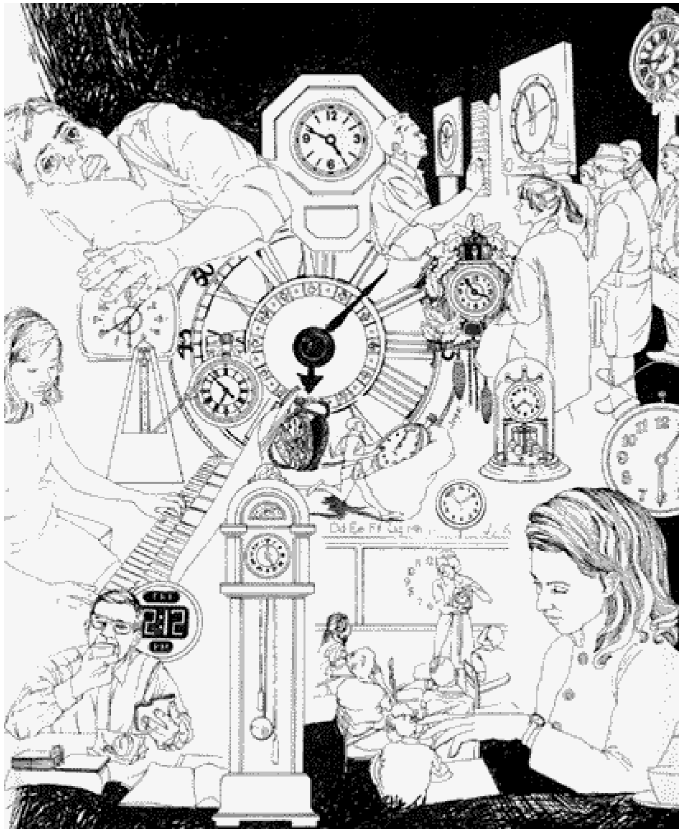
ALARA
As **L**ow **A**s **R**easonably **A**chievable

Many risks can be reduced through education, engineering controls, administrative controls and various other methods. Risk to occupational radiation exposure is no different. Risk reduction in radiation safety can be implemented by adhering to a philosophy known as ALARA - **A**s **L**ow **A**s **R**easonably **A**chievable. All personnel at a facility must be committed to the ALARA philosophy.

The four basic ways to implement **ALARA** are:

Time
Distance
Shielding
Containment

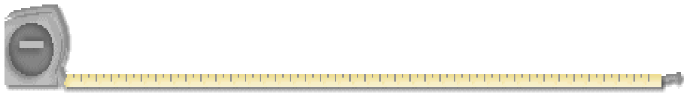
ALARA - Time



Time

When working with radiation sources, the more time you are exposed to the source, the more radiation dose you will receive, therefore minimize your time to reduce your exposure. But do not rush. Plan and rehearse experiments without radioactive materials (i.e. dry runs).

Distance



Distance is very effective for reducing exposure, therefore maximize your distance to reduce exposure. The inverse square law for reduction of radiation intensities, which applies to most sources of X-ray and gamma radiation, shows that radiation intensity is inversely proportional to the square of the distance from the source.

ALARA – Distance

The **inverse square law** is:

$$(DR_1)(X^2_1) = (DR_2)(X^2_2)$$

Where DR_1 is the dose rate at distance X_1 from a source and DR_2 is the dose rate at distance X_2 from the same source.

The above relationships are true only for photons and point sources. They are invalid for charged particles (betas) and at distances from the source that are less that a few times the maximum source dimension.

ALARA - Shielding

Any material placed between a source of radiation and personnel will absorb some of the radiated energy and decrease exposure to personnel.

Because of the statistical nature of X-ray and gamma radiation it is impossible to eliminate all transmitted radiation, however it can be reduced to acceptable levels.

The half-value layer (HVL) is the thickness of material that will reduce the photon intensity in half.

For beta emitters there is a certain thickness of any material that will eliminate all beta radiation.

Caution! Be aware of Bremsstrahlung

One word of caution regarding shielding for high energy beta emitters such as P-32. If you use shielding material with a high atomic number, such as lead, you will indeed stop the beta radiation. However, there will also be a release of electromagnetic radiation due to the deceleration of the charge particle (i.e. beta particle). Basically, you will have a small x-ray generating device with no "Off" switch. This atomic process of energy removal is known as bremsstrahlung radiation. Therefore, you should use material with a low atomic number such as **plastic.** 3/8th Inch of Plexiglas (Lucite) shielding will sufficiently shield P-32.

ALARA - Containment

Containment is about containing yourself and containing the radioactive material.

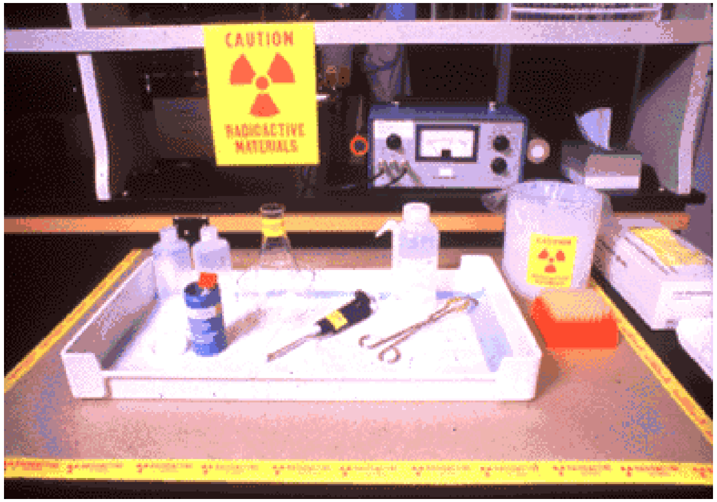
Always wear a lab coat, gloves and protective eyewear.

Do not engage in practices that will increase the probability of inhalation, ingestion or absorption of radioactive materials.

Do not eat, drink, smoke, apply cosmetics, including hand lotion, or mouth pipette in an area posted for the use of radioactive materials or posted for the storage of radioactive materials.

ALARA - Containment

To contain radioactive material:



- Keep the material in a closed storage vessel.
- Close the storage vessel as soon as practicable after dispensing the material.
- Work over trays to contain any spill.
- Cover work surfaces with absorbent disposable pads.
- Be attentive to volatility problems – use a chemical fume hood if there is a potential for aerosols, gases, dusts and vapors.
- Transport radioactive material from one location to another in a closed container within a second closed container. Make certain the outer container has sufficient absorbent material to take up twice the volume of liquid being transported.