

**Part 5 of 5**

**ALARA Training for  
Technical Support Personnel**

**Overhead Transparencies and Handouts**



**Coordinated and Conducted  
for  
Office of Health, Safety and Security  
U.S. Department of Energy**

DOE-HDBK-1110-2008

# ALARA TRAINING FOR TECHNICAL SUPPORT PERSONNEL

## Overhead Transparencies



Intro-1

# Course Content

- **Introduction to ALARA**
- **Types of radiation**
- **Selected topics in radiation protection**
- **ALARA principles**
- **Applications of ALARA to source term reduction and control**

Intro-2

## **Course Content (Cont'd.)**

- **Application of ALARA to system design**
- **Application of ALARA to civil/structural design**
- **ALARA design review**
- **ALARA operational review**
- **Optimization**

**Intro-3**

# **MODULE 101**

## **INTRODUCTION TO ALARA**

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101-1

## **Module 101 - Objectives**

- **DEFINE** the acronym ALARA
- **LIST** the ALARA recommendations of the RadCon Manual
- **IDENTIFY** which groups should participate in ALARA design reviews

# As Low As Reasonably Achievable

Taking into account:

- **social,**
- **technical,**
- **economic,**
- **practical, and**
- **public policy considerations.**

101-4

## **NCRP 116 ALARA Guidance**

- **Justification**
  - **The need to justify radiation dose on the basis of benefit**
  
- **Optimization**
  - **the need to ensure that the benefits are maximized**
  
- **Limitation**
  - **the need to apply dose limits**

∞

101-5

## **Documents that require, direct or recommend considerations for ALARA**

- **10 CFR Part 835, "Occupational Radiation Protection"**
- **DOE Radiological Control Standard**
- **Order 5400.5, Ch. 2, "Radiation Protection of the Public and the Environment"**
- **PNL-6577, "Health Physics Manual of Good Practices for Reducing Radiation Exposures to Levels that are ALARA"**

101-6

## **10 CFR Part 835, "Occupational Radiation Protection"**

- **Measures shall be taken to maintain radiation exposure in controlled areas ALARA.**
- **Where use of engineered controls is demonstrated to be impractical - administrative controls and procedural requirements shall be used.**

# **MODULE 102**

## **TYPES OF RADIATION**

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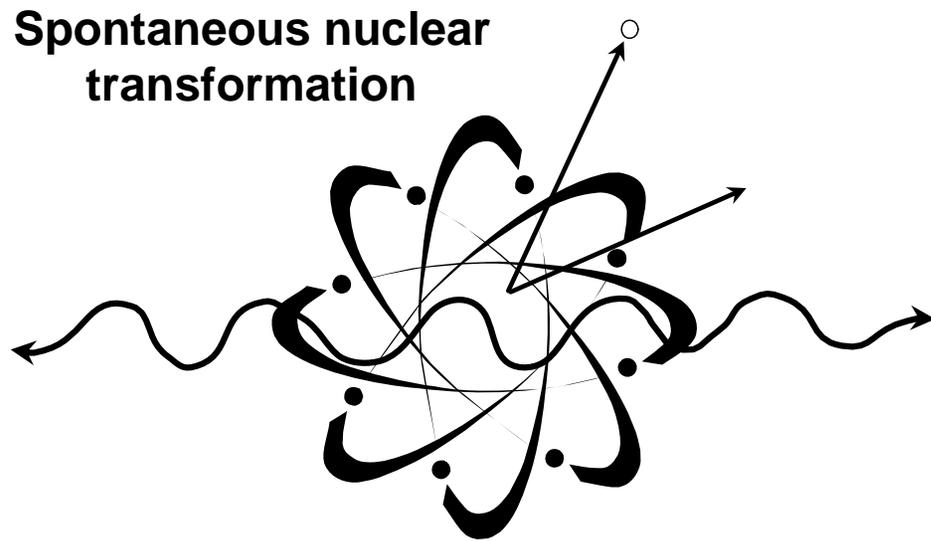
## **Module 102 - Objectives**

**Following self-study and/or classroom review, participants will be able to identify the penetrating abilities in body tissue of:**

- **alphas,**
- **betas,**
- **gammas and x-rays, and**
- **neutrons.**

**102-2**

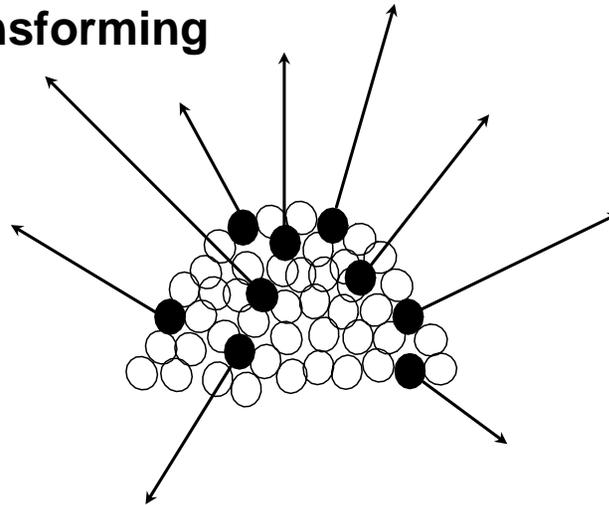
## Radioactivity may be defined as:



102-3

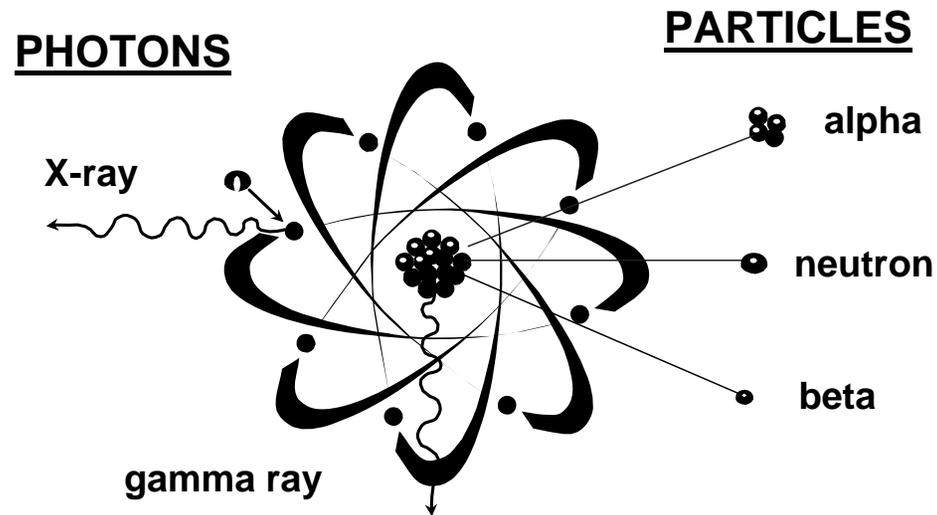
## Radioactive material contains:

Atoms whose nuclei are transforming

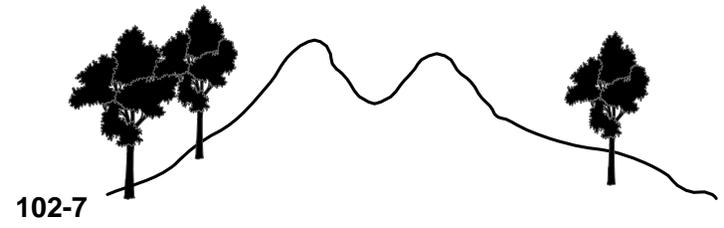
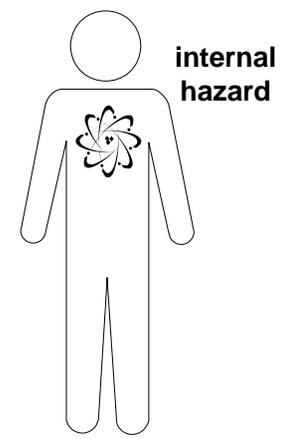
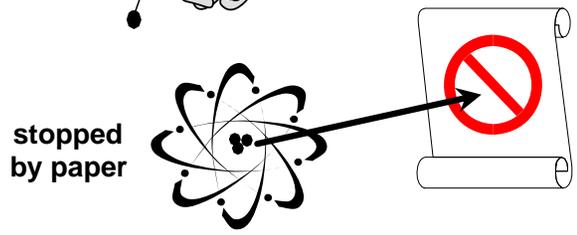
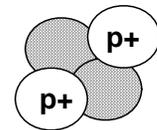


102-4

## Two general categories of ionizing radiation:



# Alpha particles are highly energetic helium nuclei



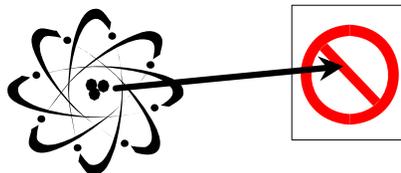
soil, radon, and heavy man-made elements

## Beta particle: an energetic electron from an unstable nucleus

skin, eye, and  
internal hazard



stopped  
by plastic



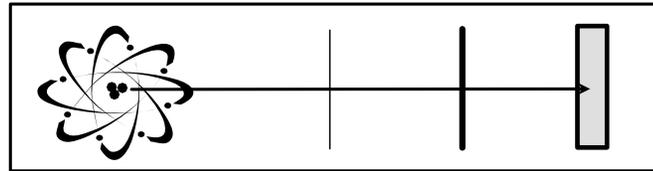
natural food, water, air



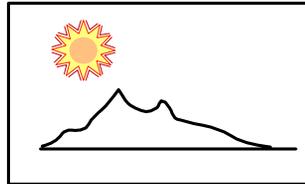
102-8

# Gamma and X-rays are photons (massless electromagnetic energy)

stopped by  
dense shielding

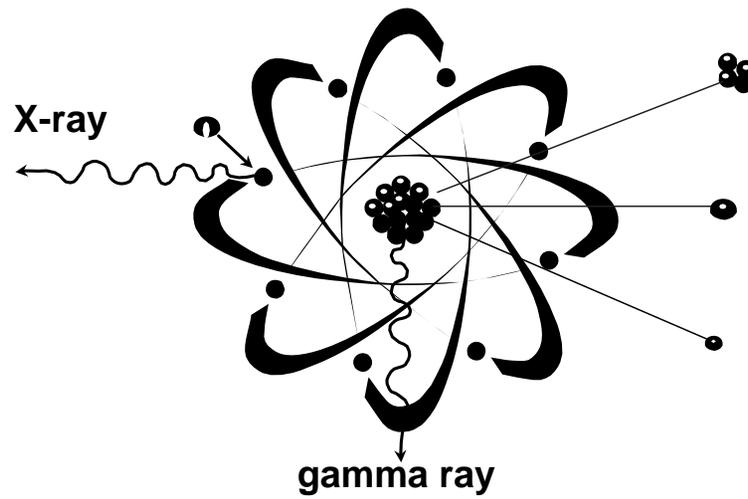


naturally present  
in soil and in  
cosmic radiation



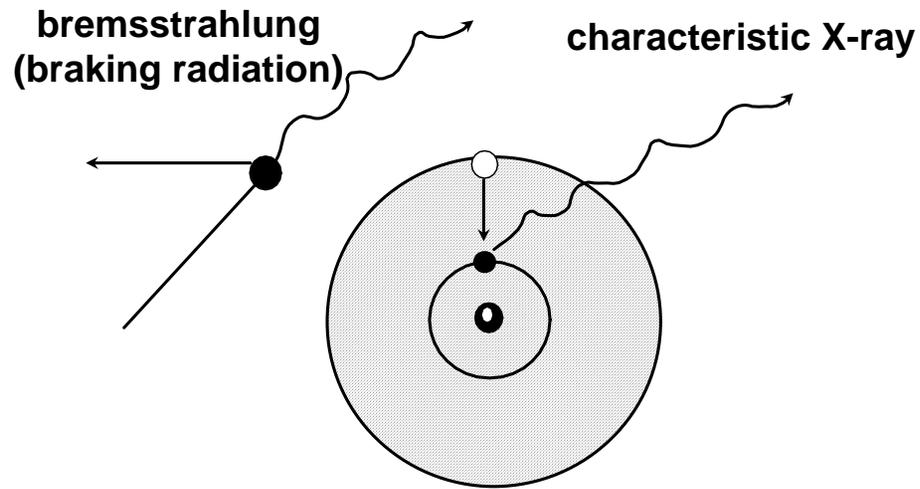
medical,  
radioactive  
materials

# Gamma and X-rays are identical except for their origin

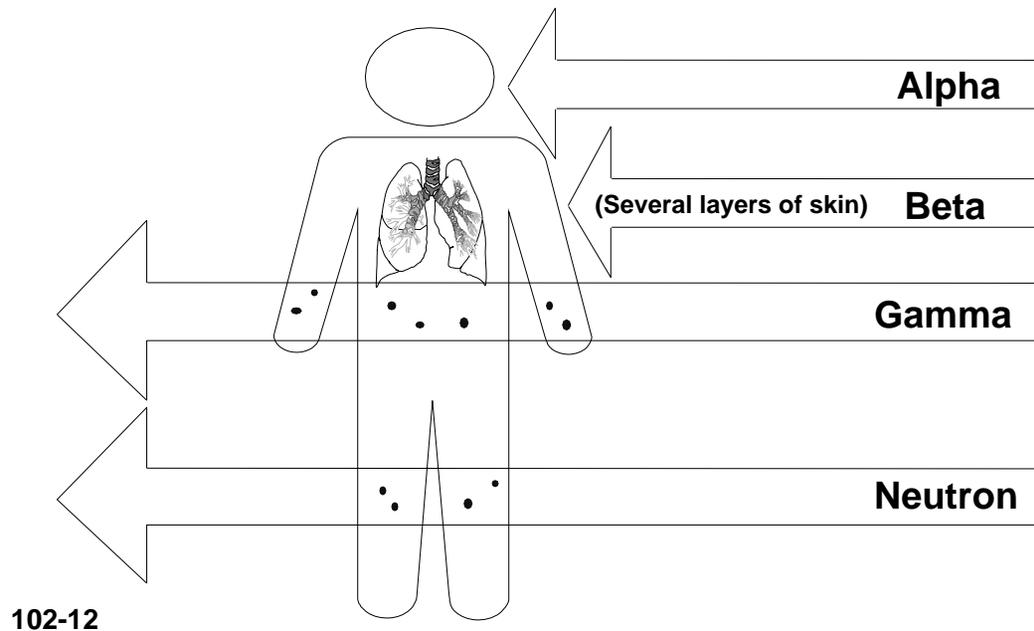


102-10

# X-rays come from two sources



# Relative penetrating ability of ionizing radiation in tissue



# **MODULE 103**

# **SELECTED TOPICS IN RADIATION PROTECTION**

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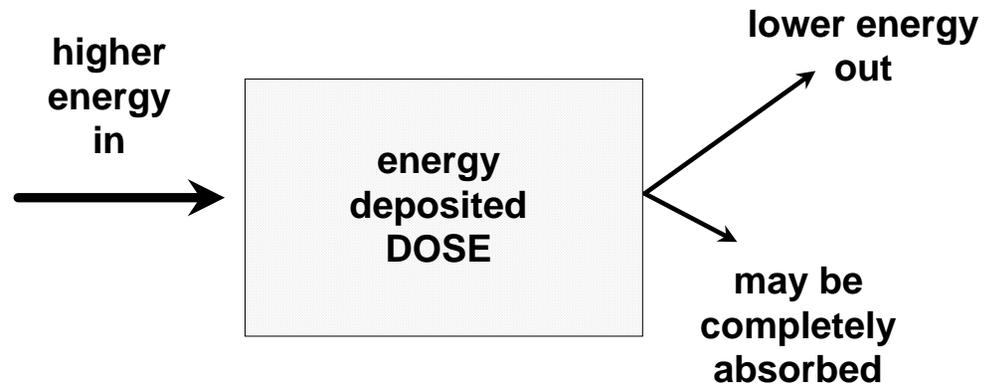
## Module 103 - Objectives

Following self-study and/or classroom review, trainees will be able to:

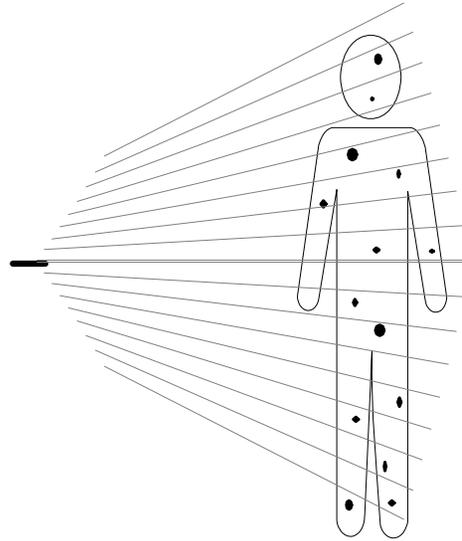
- **LIST** four ways radioactive material enters the body.
- **DEFINE** the terms "crud" and activation products.
- **DISCUSS** controls for airborne radioactive material.
- **DISCUSS** methods to process radwaste.
- **DEFINE** the terms "Controlled Area" and "Radiological Area." **DISCUSS** types of radiological areas.
- **IDENTIFY** types of contamination control measures.
- **DEFINE** scattering and streaming.

103-2

## Radiation interacts with the body by depositing its energy in the cells

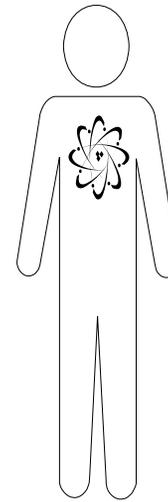


# Dose can be delivered by external or internal sources



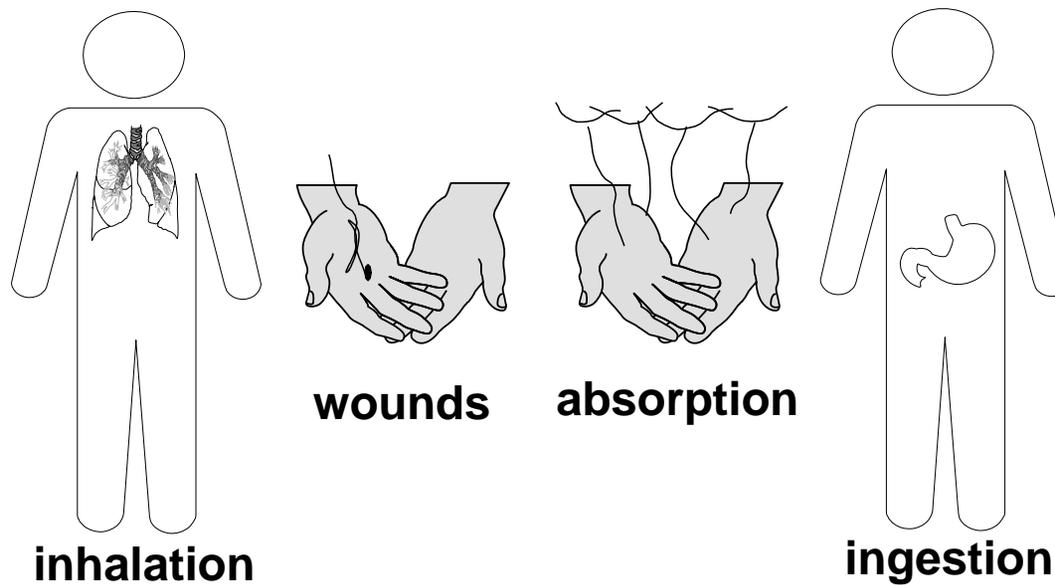
**External**

103-4



**Internal**

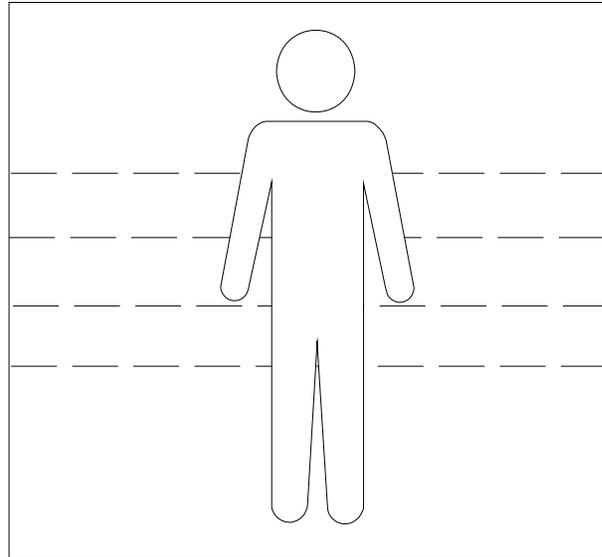
## Radionuclides can enter the body in four ways



103-5

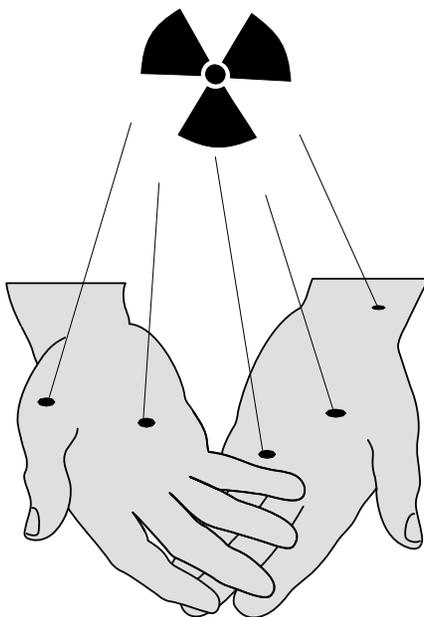
## Whole-body dose normally results from penetrating radiation

**X-rays  
gamma rays  
neutrons**



103-6

## Skin dose may also be delivered by weakly penetrating radiation

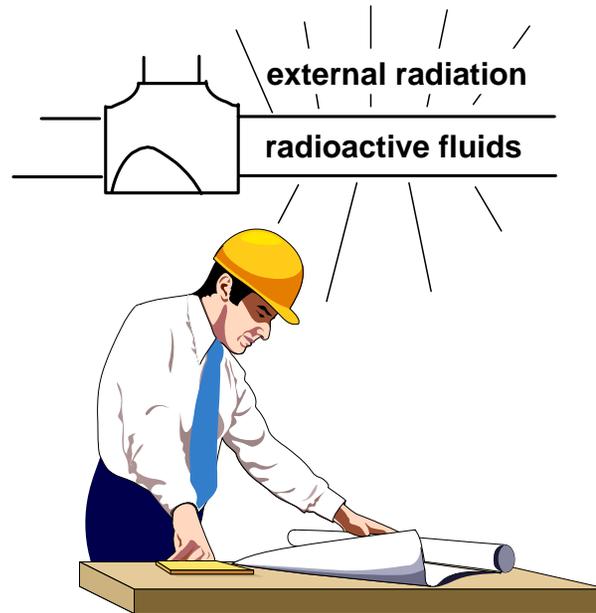


## **Extremity dose may result from:**

- **Handling a source or**
- **Working in a non-uniform field.**

# CRUD is waterborne contamination that:

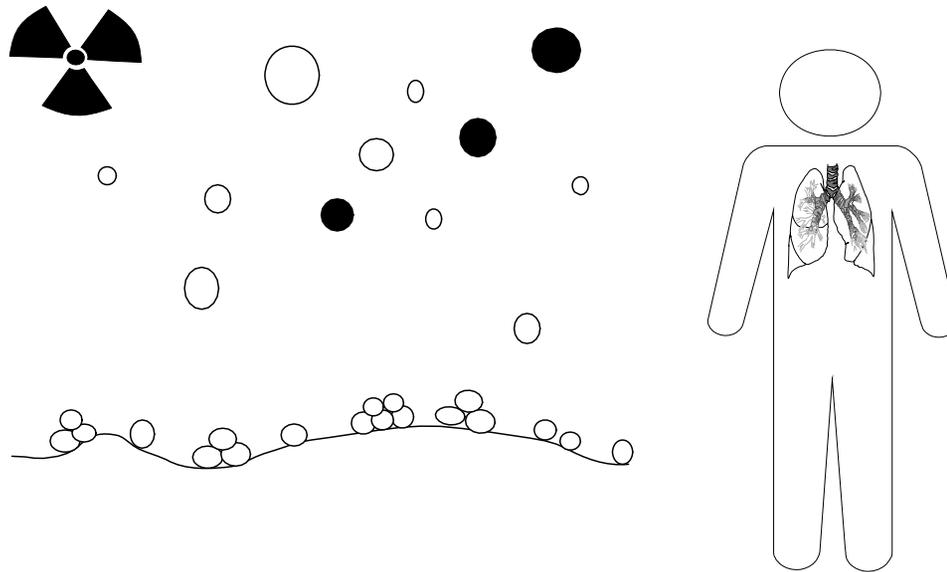
may deposit as solids in unfavorable spots.



## **Some of the best means to reduce the production of CRUD are to:**

- **Use low-activation materials so that CRUD is not produced,**
- **Prevent corrosion and erosion of equipment, and**
- **Avoid CRUD traps, such as low-flow areas.**

## Airborne radioactive materials are of particular concern



103-11

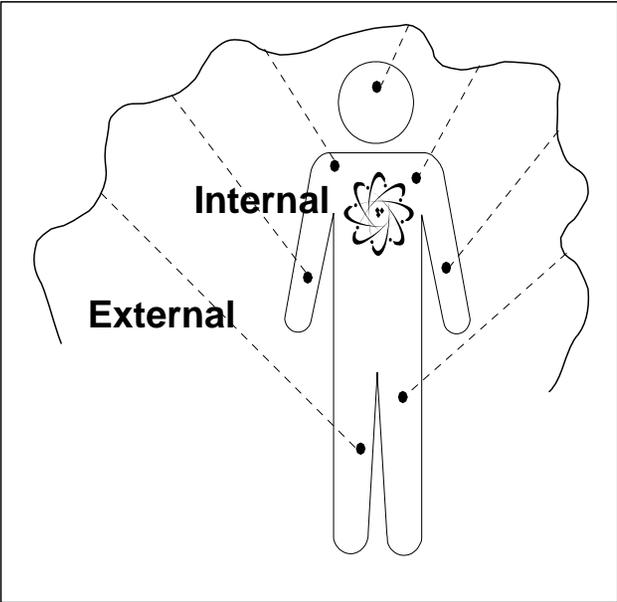
## **Radioactive materials may become airborne by:**

- **Release of a gas, such as krypton, xenon, etc.,**
- **Chemical reactions,**
- **Volatilization of liquids, and**
- **Solid materials (particulates) dispersed in air.**

103-12

# Airborne radioactive materials may create --

**an external hazard as well as an internal hazard.**



## **Protection from airborne hazards may include wearing:**

- **a respirator,**
- **a nonporous suit in atmospheres  
containing absorbable radionuclides,  
and**
- **protective clothing.**

103-14

# Do not eat, drink, or smoke in radiological areas

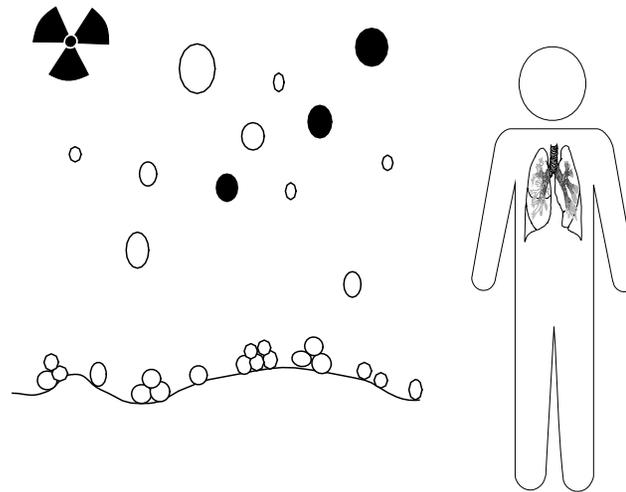


103-15

# Airborne radioactivity limits are expressed in terms of:

## Derived Air Concentrations (DAC)

Breathing 1 DAC for 2000 hours (1 work-year) would result in the annual limit (5 rem wholebody or 50 rem organ).



**Minimization of dose may mean --  
don't wear a respirator**

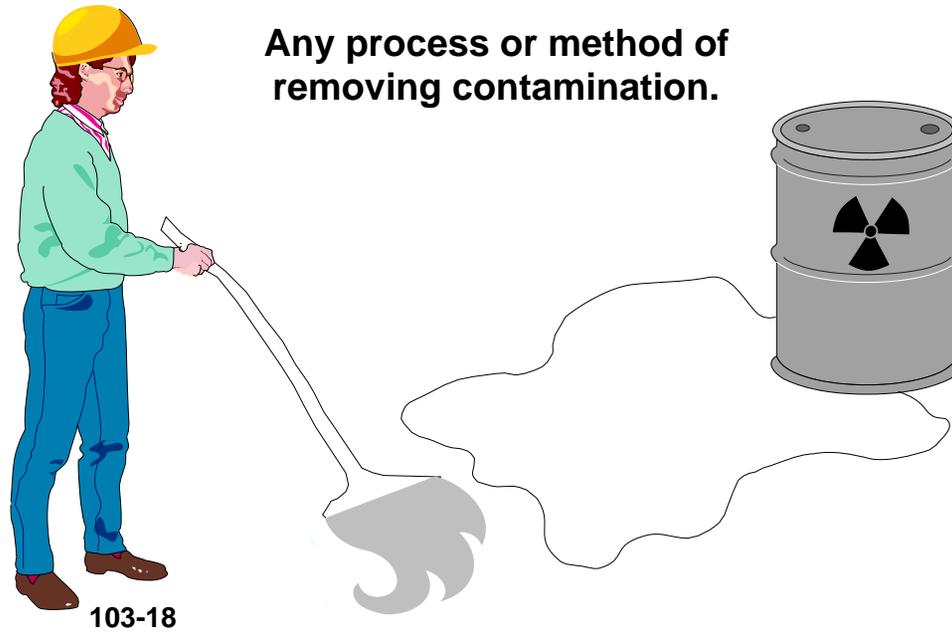
**HEALTH RISK** to the worker may be increased because of heat stress, industrial safety concerns, etc.

**WORK EFFICIENCY** may be decreased due to use of respiratory protection, resulting in increased external exposure.

**Other controls may be more appropriate!!**

## Decontamination is --

Any process or method of removing contamination.



103-18

## Provisions for decontamination

- **Design,**
- **Planning,**
- **Methods, and**
- **Fixed and removable equipment.**

**Radioactive waste or  
radwaste is:**

**Any radioactive  
material or  
substance that is not  
considered useful  
and must be  
disposed of.**

## **Types of radwaste include:**

- **Solid dry waste (dry active waste) - DAW,**
- **Liquid, and**
- **Gaseous.**

## **Methods of processing radioactive waste may include:**

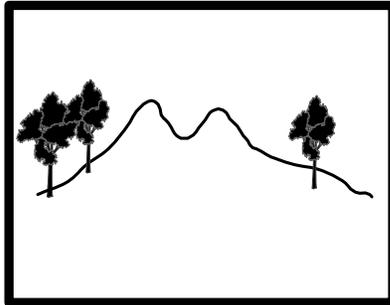
- **Filtration,**
- **Volume reduction (incineration or compaction,**
- **Ion exchange processes,**
- **Decay tanks and other containments, and**
- **Dilution.**

# Special consideration needs to be given to generation of mixed waste

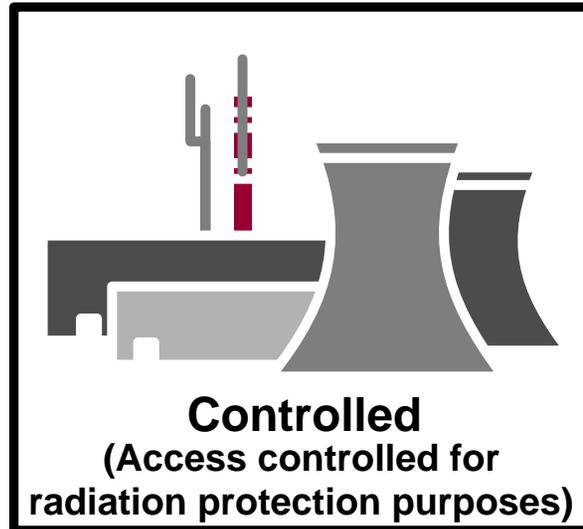
**Minimize, Minimize,  
Minimize!!**



## Controlled and Uncontrolled Areas

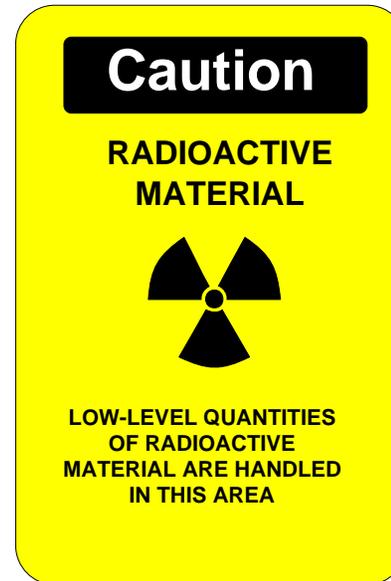
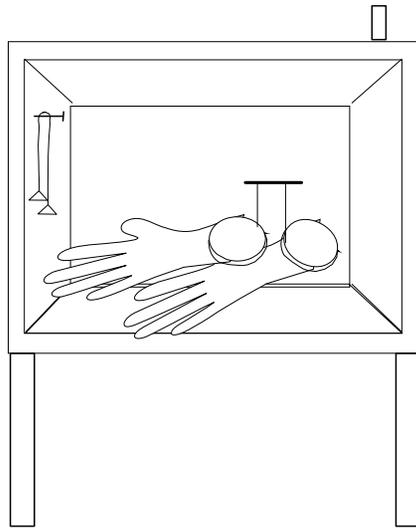


**Uncontrolled**  
(Unrestricted access)



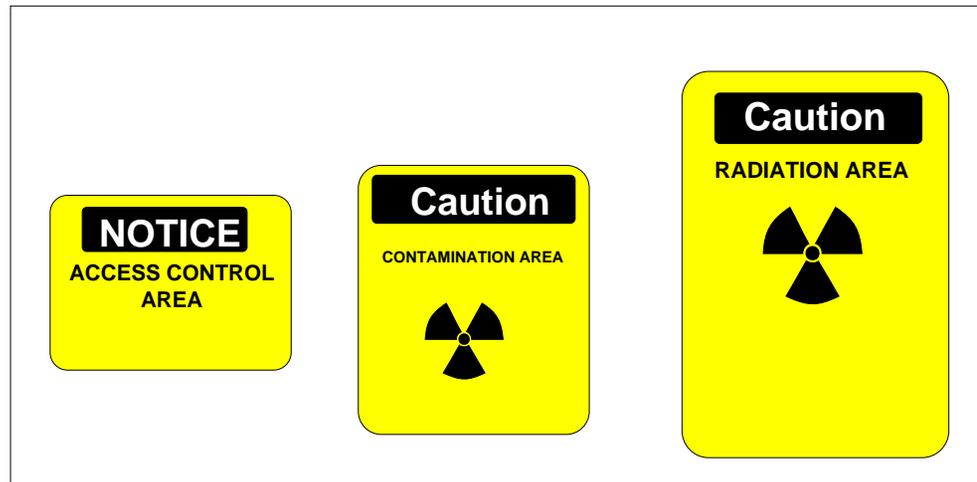
**Controlled**  
(Access controlled for  
radiation protection purposes)

## Radioactive Material Area may be an area or structure



# Radiological Areas

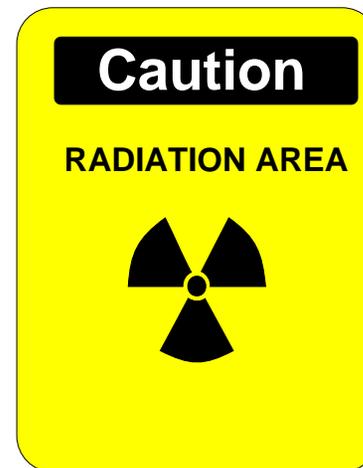
GERT/Visitor Orientation or escort required for entry



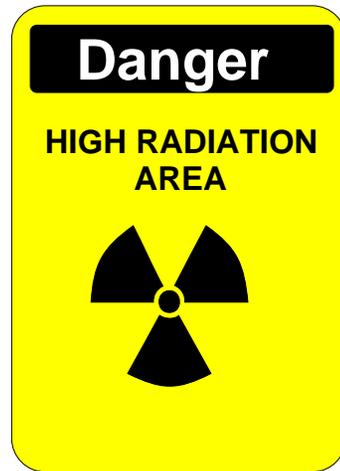
103-26

## A Radiation Area is:

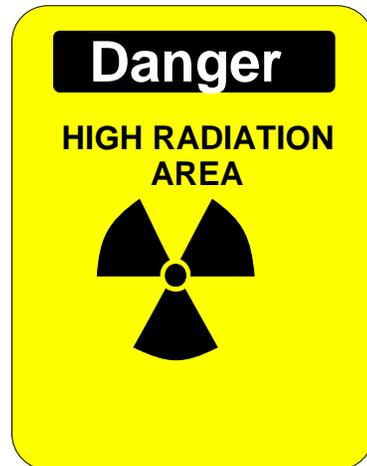
**Greater than  
5 mrem/hr  
but not more  
than 100  
mrem/hr.**



## Areas of Potentially High Dose Rates



## A High Radiation Area is:

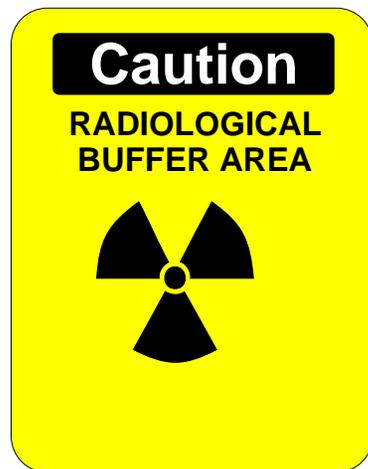


**Greater than  
0.1 rem/hr but  
not more than  
500 rad/hr.**

**VERY HIGH  
RADIATION AREA  
> 500 rad/hr**

103-29

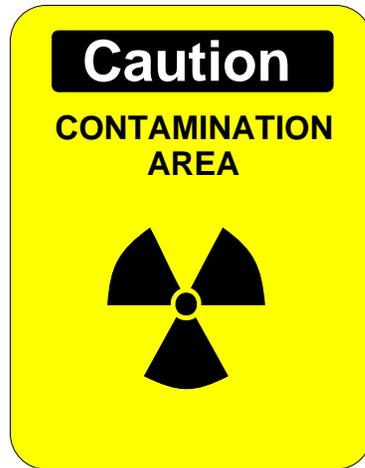
**A Radiological Buffer Area may be established for secondary control.**



- **Area adjacent to any exit or entry from Contamination Area.**
- **Surround or be contiguous with Radiation Area.**

103-30

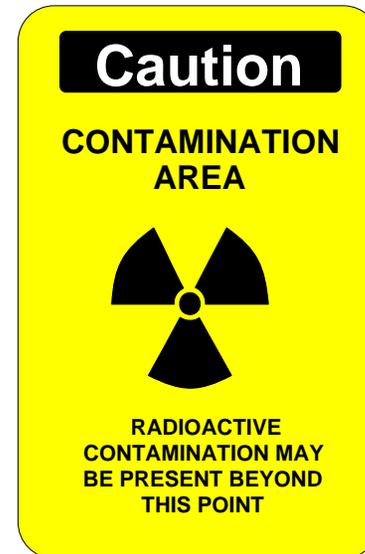
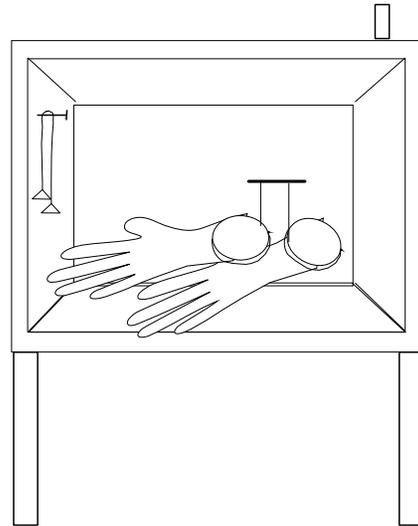
**A Contamination Area has contamination levels greater than release values.**



**High  
Contamination  
Area**

**> 100 X Values**

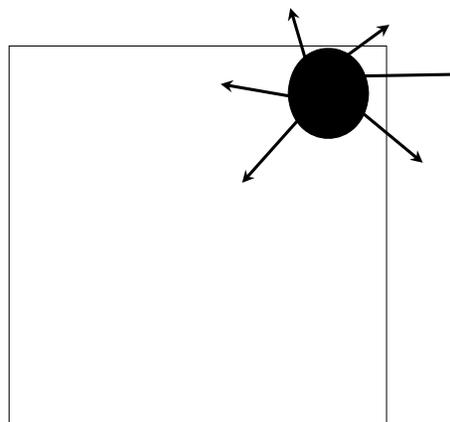
## Areas of Potential Surface and Airborne Contamination



103-32

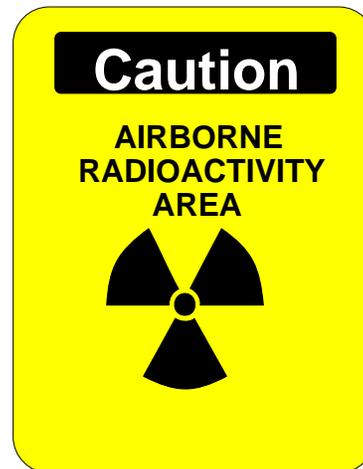
**Hot Spot is a localized area  
where contact dose rates are:**

**>100 mrem/hr  
AND > 5 X  
general area  
dose rates.**



**An Airborne Radioactivity Area  
has levels:**

**greater than  
the DAC or  
12 DAC-hrs in a  
week**



## **Some common entry control measures include:**

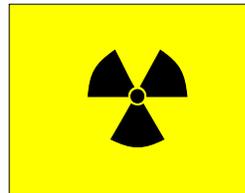
- **Signs and barricades**
- **Control devices on entrances**
- **Visible or audible alarms**
- **Locks**
- **Administrative controls**

## **Some types of contamination control measures include:**

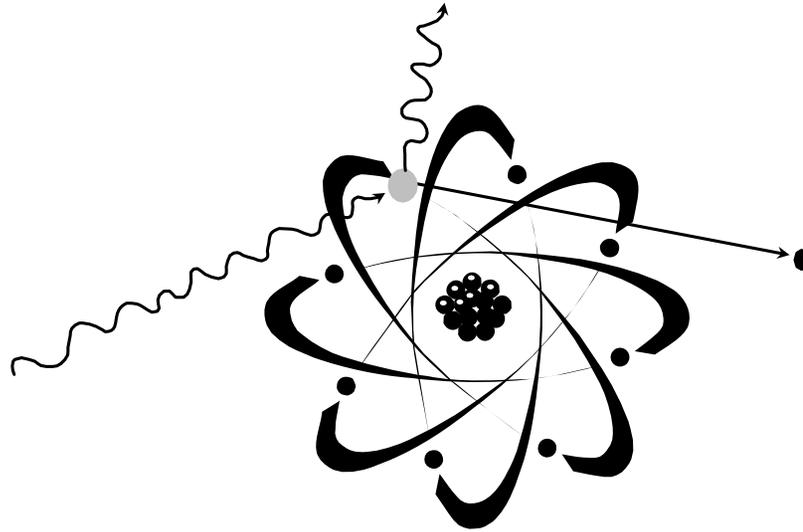
- **Step-off pads**
- **Protective clothing**
- **Containment**
  - **Gloveboxes**
  - **Hot cells**
- **Effective ventilation**

**An area may have  
intermittent hazards**

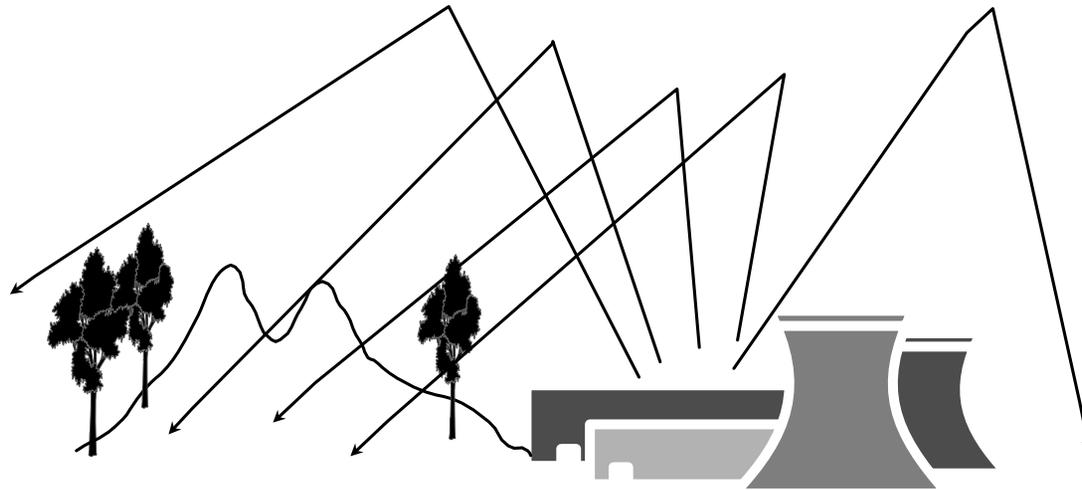
**BEWARE!!**



**Scatter is reflected radiation, such as a neutron or photon**



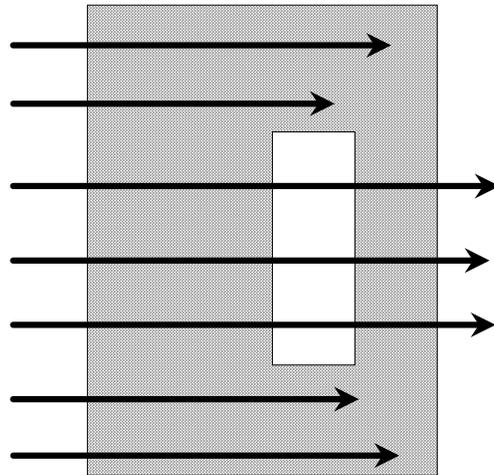
## Outside air can provide significant scatter, "skyshine"



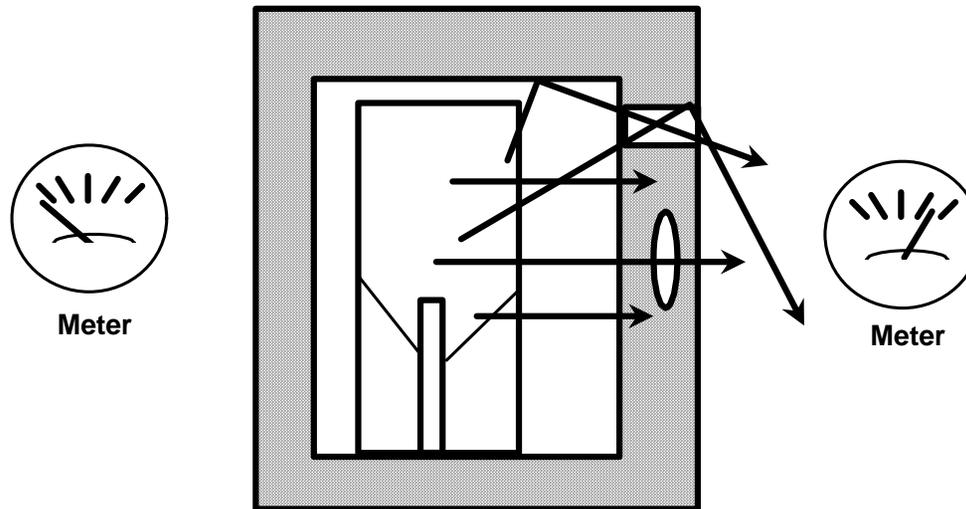
60

103-39

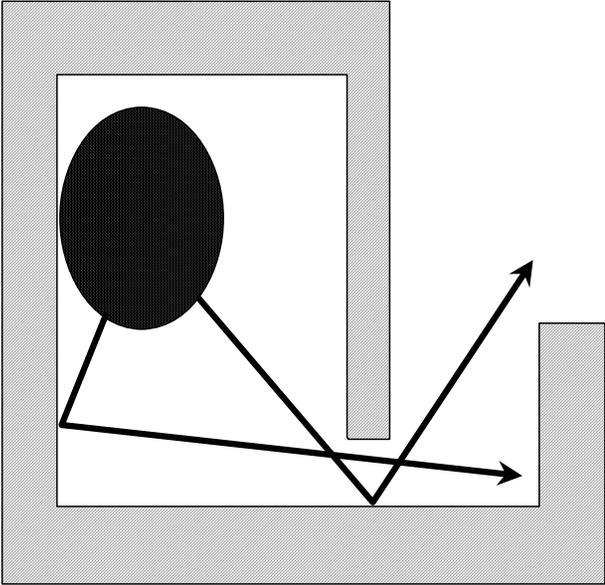
**Streaming results when radiation passes through an opening or void in shielding**



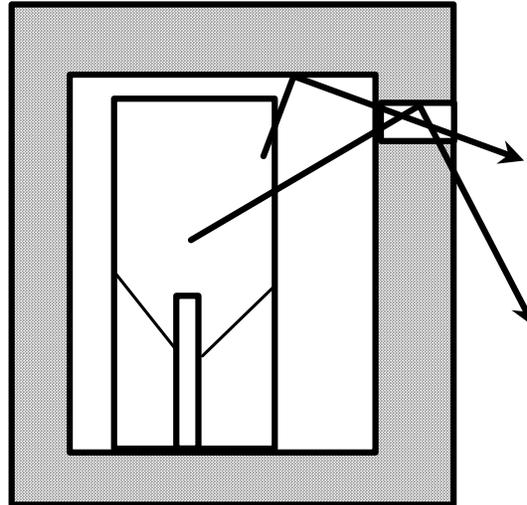
## Scattering and streaming may result in a significant dose rate outside the shield



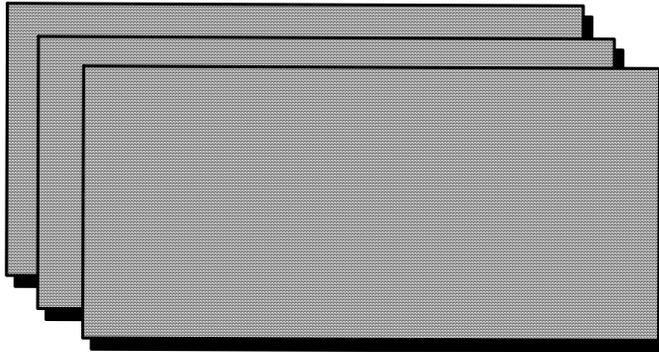
# Scatter paths may occur through a labyrinth entrance



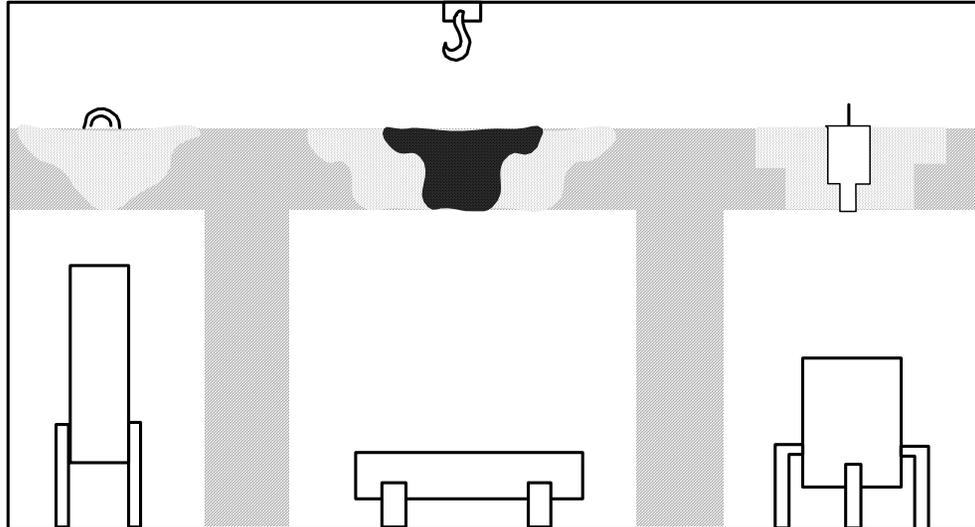
## Scatter paths may occur through a penetration



## Removable, overlapping block walls may be used to minimize streaming

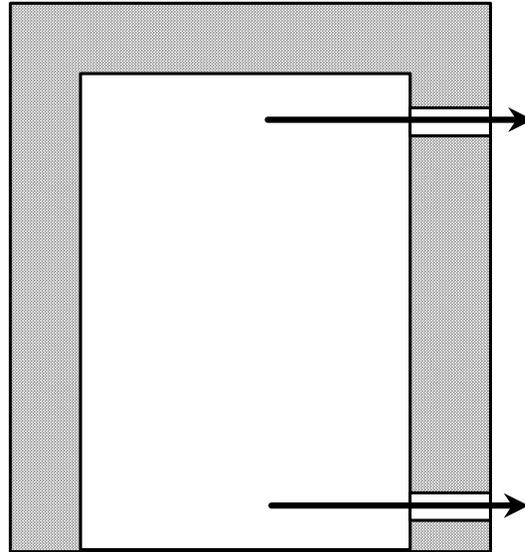


## Typical shield slabs and plugs



103-45

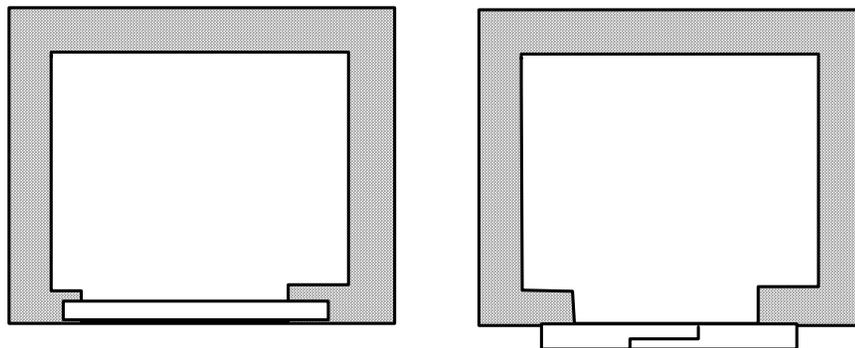
## Pass-through ports should be placed near the floor or ceiling



103-46



## Shield door or shield slab arrangement



# **MODULE 104**

## **ALARA PRINCIPLES**

## Module 104 - Objectives

Following self-study and/or classroom review, participants will be able to:

- **IDENTIFY** the six fundamental principles used to reduce radiation dose and the release and spread of radioactive materials.
- **IDENTIFY** applications of the fundamental principles.
- **IDENTIFY** appropriate shielding materials used to reduce radiation exposures.

104-2

## **Six fundamental principles should be considered**

- **Eliminate or reduce the source of radiation,**
- **Contain the source,**
- **Minimize time in a radiation field,**
- **Maximize distance from a radioactive source,**
- **Use radiation shielding, and**
- **Optimize resources.**

# Hierarchy of Controls

**Engineered Controls**



**Administrative controls**

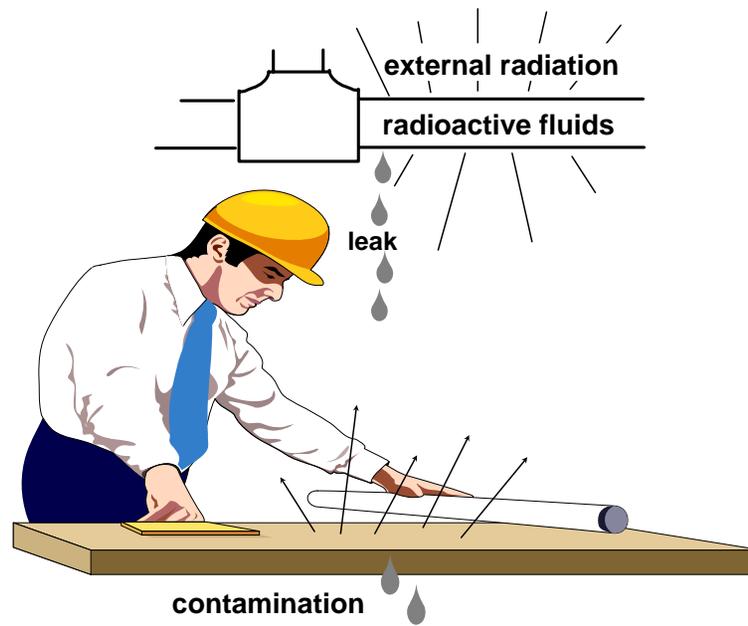


**Personnel protective measures**

## **The first ALARA design principle is to eliminate or reduce the source**

- **Removal of source or source elimination,**
- **Source reduction, or**
- **Radioactive decay.**

## The second ALARA design principle is to control and contain radioactivity



104-6

## **Methods to control and contain radioactive sources include:**

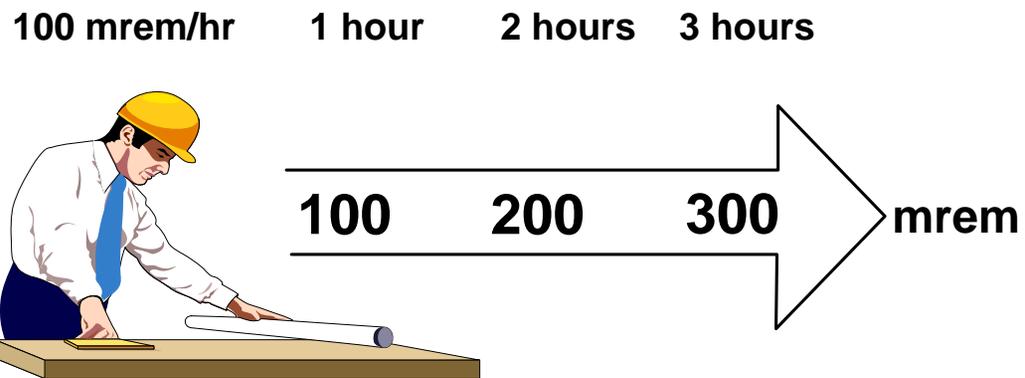
- **Containment**
  - leak-tight enclosures
- **Ventilation**
  - circulation, exchange, and filtration of air
- **Filtration**
  - circulation, exchange, processing, and filtration of water or air

104-7

## **Protective designs include such items as:**

- **Ventilated fume hoods,**
- **Gloveboxes,**
- **Exhaust systems,**
- **Water filtration systems, and**
- **Oversized ventilation cleanup systems.**

## The third ALARA design principle is to reduce the time in a radiation field



## **Design factors to reduce time spent in radiation fields include:**

- **Install reliable equipment to reduce maintenance,**
- **Provide adequate clearance for maintenance and inspections,**
- **Utilize special tools to speed maintenance and access,**
- **Remove components from radiological area for repair and calibration, and**
- **Install permanent lighting and platforms.**

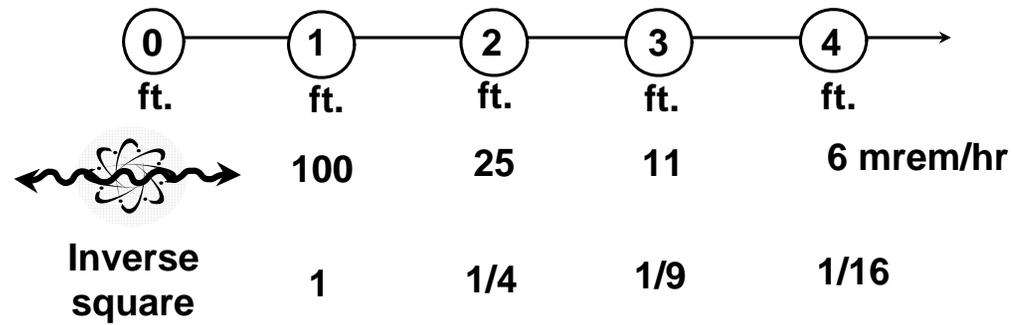
104-10

## Typical Distance in Air

- **Alpha:** 1 - 2 inches
- **Beta:** 10 - 12 feet per MeV of energy
- **Gamma:** very long range (weakly interacting)
- **Neutron:** very long in air

104-11

## The fourth ALARA design principle is to maximize distance from source



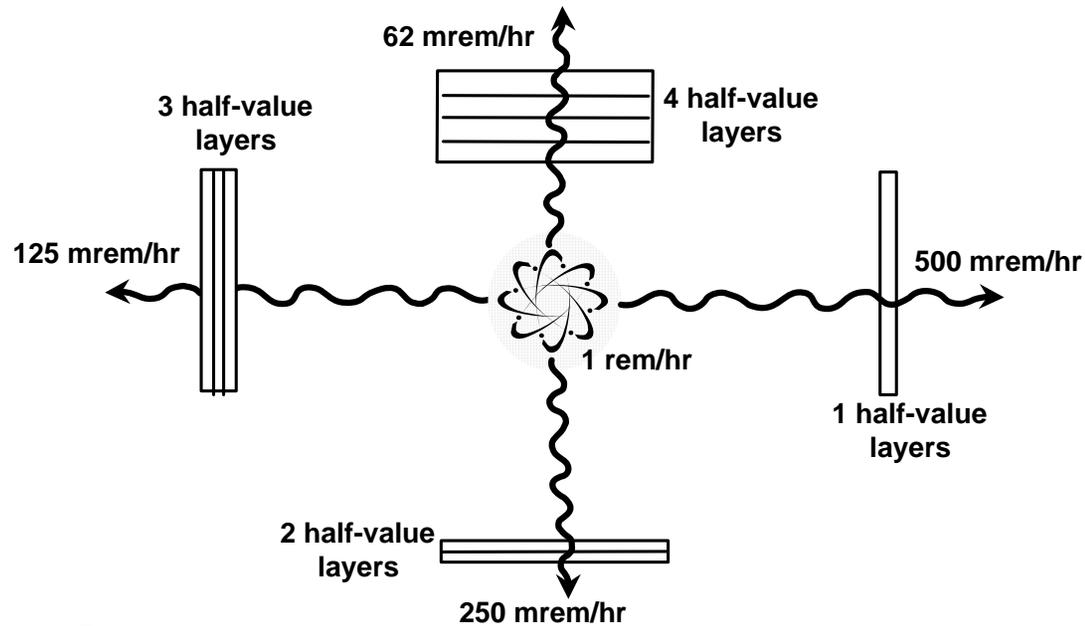
**Design factors to maximize the distance from radioactive sources include:**

- **Remote operations,**
- **Locating instruments and readouts in low dose areas,**
- **Provision for removal of components to low dose areas for maintenance, and**
- **Use of remote handling tools for repair, maintenance, and operations.**

**Design factors to maximize the distance from radioactive sources include (cont'd):**

- **Use of cameras and microphones to perform remote surveillance and inspections, and**
- **Equipment should be laid out so as to maximize the distance between workers and the radiation source.**

**The fifth ALARA design principle is to use shielding between worker and source**



## **When incorporating shielding into design you should:**

- **Anticipate crud buildup and hot spots,**
- **Use labyrinths for entry and exit,**
- **Install special shields,**
- **Consider space and access for installing temporary shielding, and**
- **Use appropriate shielding materials.**

## Typical shielding materials for the various types of radiation include:

- **Alpha:** stopped by piece of paper;
- **Beta:** 1/2 inch Plexiglass, 1/4 inch aluminum -  
Due to creation of bremsstrahlung consideration  
must be given to shielding X rays;
- **Gamma:** lead, concrete, steel (high-density  
materials); and
- **Neutron:** water, polyethylene, concrete  
(hydrogenous materials).

## **Other factors to consider:**

- **Use fortuitous shielding whenever possible.**
- **Correctly layer shielding for structural integrity and attenuation of different types of radiation.**
- **Consider using concrete for stopping any type of radiation.**
- **Dirt is cheap.**

## **The sixth ALARA design principle is optimization**

**Designing to ALARA uses the cost-benefit process of optimization to achieve ALARA.**

## Summary - Objectives

- Define the acronym ALARA.
- List the ALARA requirements of the RadCon Manual.
- Identify which groups should participate in ALARA design reviews.
- Identify the penetrating abilities in body tissue of:
  - alphas,
  - betas,
  - gammas and x-rays, and
  - neutrons.

## Summary - Objectives (cont'd.)

- **List four ways radioactive material enters the body.**
- **Define the terms "crud" and activation products.**
- **Discuss controls for airborne radioactive material.**
- **Discuss methods to process radwaste.**
- **Define the term "Controlled Area" and "Radiological Area." Discuss types of radiological areas.**
- **Identify types of contamination control measures.**

## Summary - Objectives (cont'd.)

- **Define scattering and streaming.**
- **Identify the six fundamental principles used to reduce radiation dose and the spread of contamination.**
- **Identify applications of the fundamental principles.**
- **Identify appropriate shielding material used to reduce radiation exposures.**

# **MODULE 105**

# **APPLICATIONS OF ALARA**

DOE-HDBK-1110-2008

## **Module 105 - Objectives**

**During the presentation of  
Module 105, participants  
should be able to  
demonstrate the  
application of ALARA  
principles of source term  
reduction and control.**

## **Control radioactive material deposition in liquid systems by reducing:**

- **Crud production,**
- **Erosion,**
- **Corrosion loss, and**
- **Deposition.**

## **Avoid use of nickel, cobalt or other readily activated material in high neutron fields**

- **Surfaces in contact with reactor coolant systems,**
- **Surfaces near neutron emitters, and**
- **In accelerators that produce neutrons.**

## **Reduce the loss of material by erosion**

- **Use good flow geometry.**
- **Avoid sharp bends, reducers, and rough internal surfaces.**

## **Reduce the loss of material by corrosion**

- **Use corrosion-resistant materials.**
- **Pretreat or precoat surfaces.**
- **Use pH and other chemistry controls.**
- **Provide for wet layup during maintenance and shutdown periods.**

## **Reduce deposition of CRUD and/or other radioactive material circulating in the system**

- **Select appropriate flow velocities.**
- **Provide strainers.**
- **Ensure that all equipment and piping runs are drainable and flushable.**
- **Minimize crevices, elbows, low points, sharp bends, and dead legs.**

105-7

## **Reduce deposition of CRUD and/or other radioactive material circulating in the system (cont'd.)**

- **Generally use butt welds, consumable inserts, and freeze fits (smoother welds).**
- **Generally use full-ported valves (plug, gate, or ball valves instead of globe valves).**
- **Choose straight-tube, vertical heat exchanger rather than U-shaped, horizontal ones.**

## **Provide for proper contamination control measures**

- **Contamination in one area should not result from minor or moderate incidents that occur in any other radiological area.**
- **Outside radiological areas, radioactive surface contamination should not exceed release values.**
- **Select equipment that can be readily, easily, and completely dismantled.**

## **Provide for equipment decontamination**

**It is ALARA to select a  
method that reduces the  
dose to the worker while  
reducing the volume of  
radwaste produced.**

## **MODULE 106**

# **APPLICATIONS OF ALARA TO FACILITY AND SYSTEM DESIGN**

101

106-1

DOE-HDBK-1110-2008

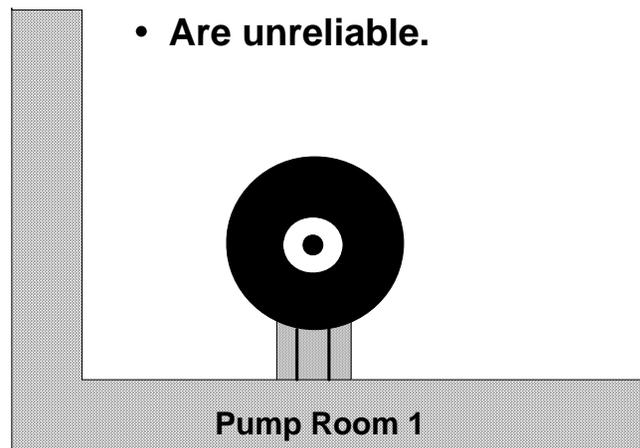
## **Design features and ALARA considerations:**

- **Reliability and equipment qualification;**
- **Ventilation;**
- **Mechanical/electrical;**
- **Radwaste systems; and**
- **Sampling, monitoring, and instrumentation.**

106-2

## The engineer must consider which components --

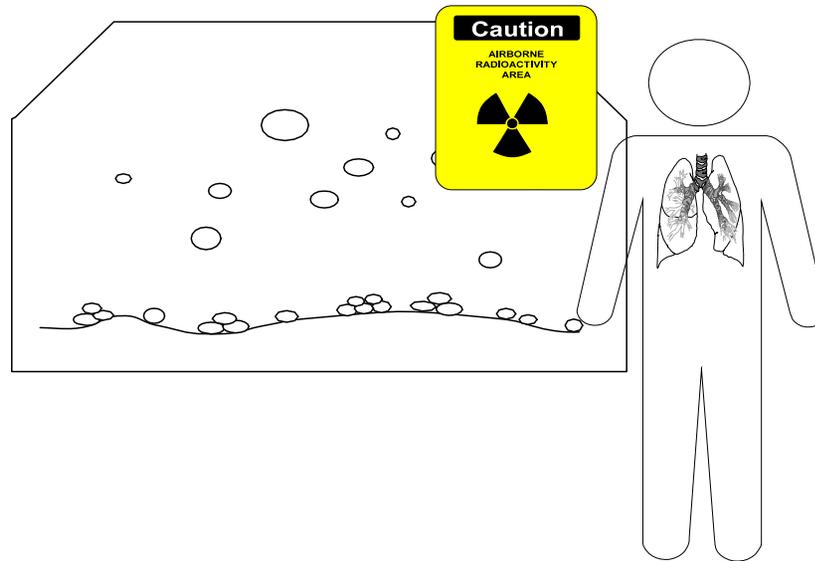
- Require large amounts of maintenance.
- Are unreliable.



106-3



# Materials and equipment selection qualification for the expected use



# **Airborne Radioactivity and HVAC**

DOE-HDBK-1110-2008

105

106-5

**Ventilation systems provide protection  
during the following two tasks:**

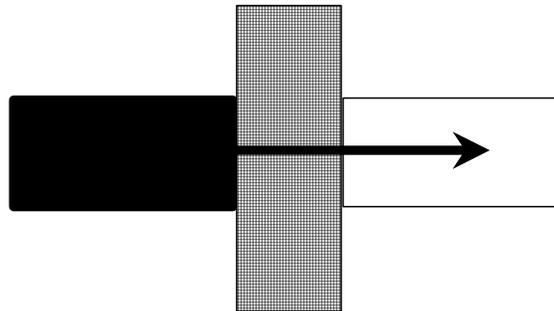
- **Normal work**
- **Accidental releases**

## Ventilation systems must have two essential features:

Appropriate  
Differential  
Pressure (DP)



High Efficiency  
Particulate Air  
(HEPA) Filtration



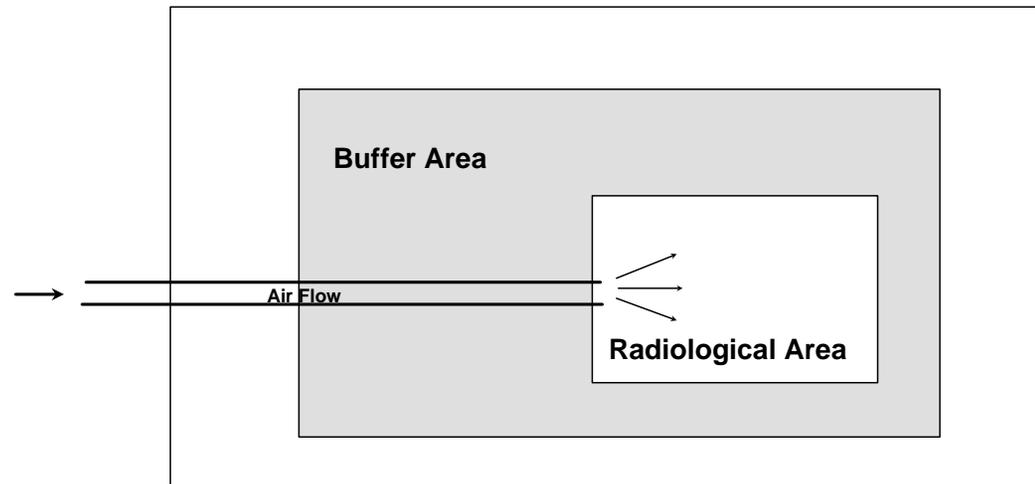
**A System of  
Differential  
Pressure Should  
be Used**

108

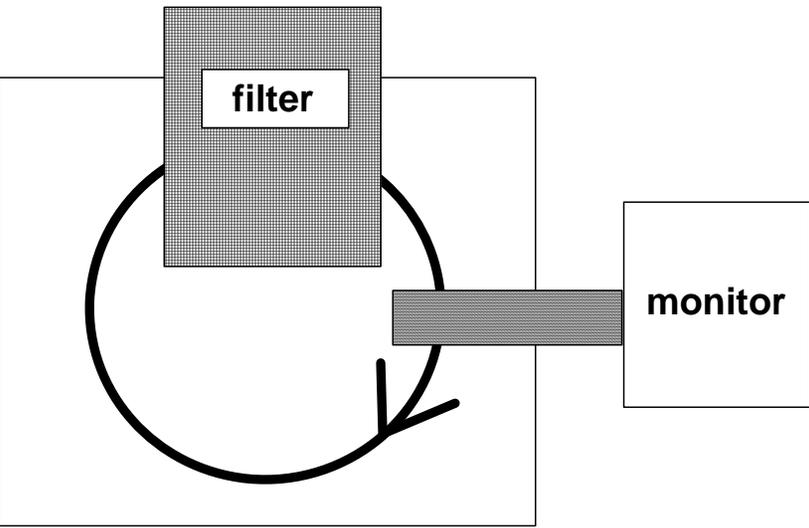
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106-8

## Direct air flow from areas with less to higher potential for contamination



**Room air may be recirculated - if adequately filtered and monitored**



**Avoid drawing  
contaminated air  
across walkways,  
work areas, and  
breathing zones**

**For ventilation and filtration, the design engineer should address:**

- **Proper type/location,**
- **Ease of maintenance, and**
- **Monitoring.**

**Similar areas do not always require identical ventilation characteristics**

**Ventilation design criteria need to accommodate a measure of flexibility. This is essential for localizing and containing airborne radioactive contamination.**

# Containment

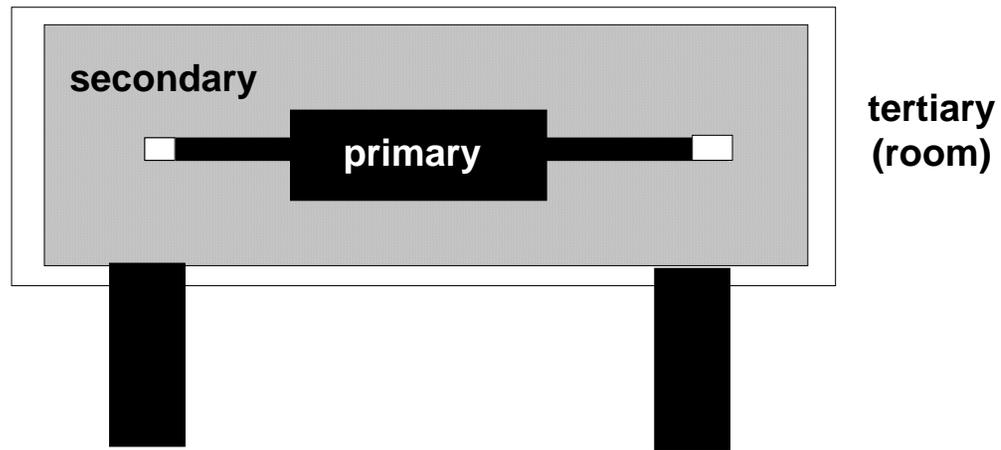
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106-14

114

# Containment is an area --

enclosed by a set of barriers either passive or active.



## **Gloveboxes and other handling enclosures are --**

- **Primary containments when materials are handled, processed, or stored in open containers or not contained at all.**
- **Gloveboxes are secondary containments when the radioactivity is actually contained in a piping system, vessel, instrument, etc., inside the box.**

# **Mechanical and Electrical Systems**

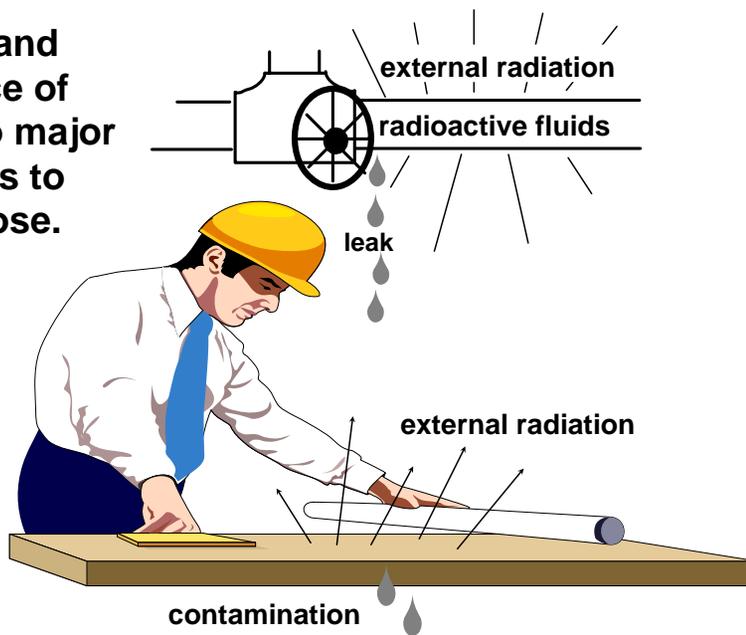
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106-17

# Valves

Operation and maintenance of valves are two major contributors to workers' dose.



106-18

## **Generally use full ported valves:**

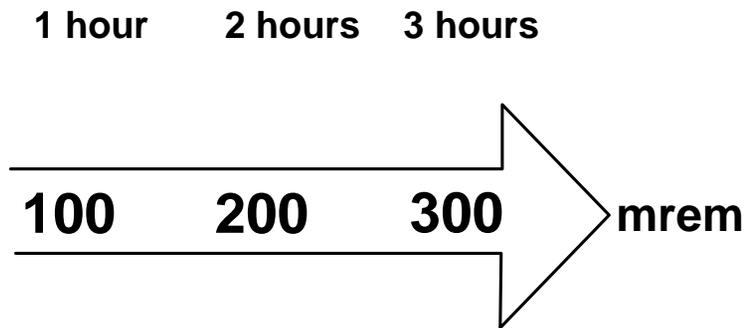
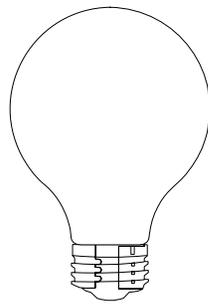
- **Plug,**
- **Gate, or**
- **Ball valves.**

# Pumps

**Pumps and valves can  
be a source of dose  
and contamination  
during maintenance or  
repair.**

# Electrical Systems

The use of long-life bulbs can decrease maintenance time.



106-21

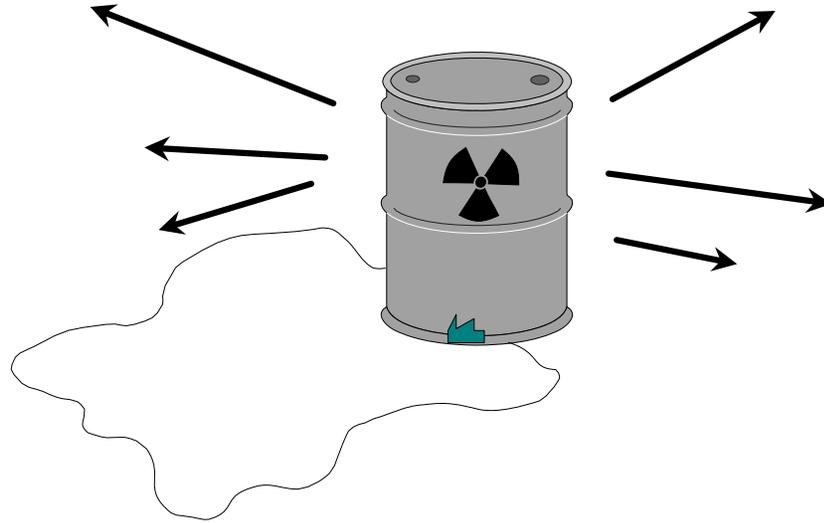
# **MODULE 107**

## **APPLICATION OF ALARA FOR VARIOUS ENGINEERING DISCIPLINES**

**This module addresses radiation dose assessment and radiological design considerations of new facilities and the modification of existing facilities.**

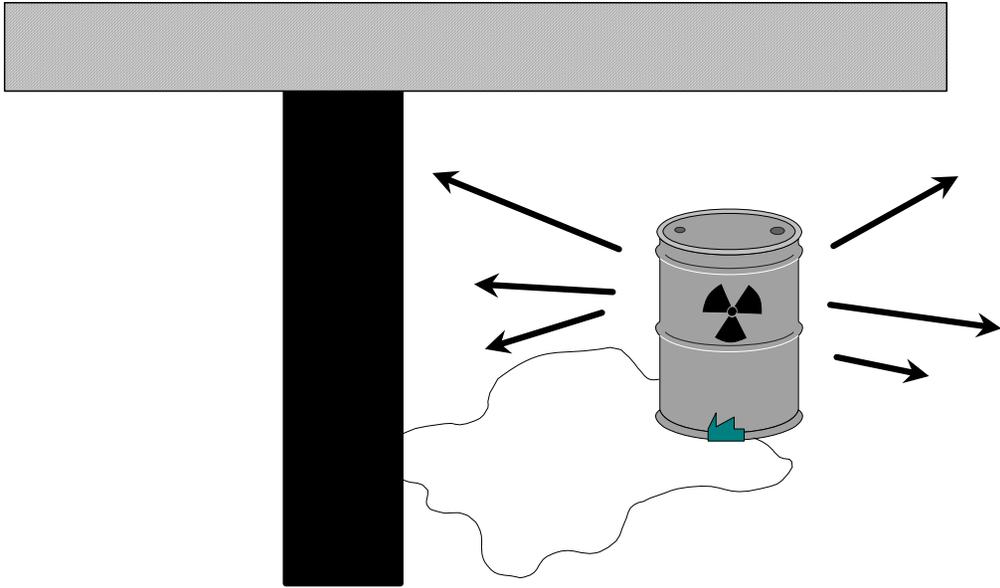
107-1

## Radiological designs should address anticipated dose risk



107-2

**Support structures can provide shielding  
but could also hinder maintenance**



107-3

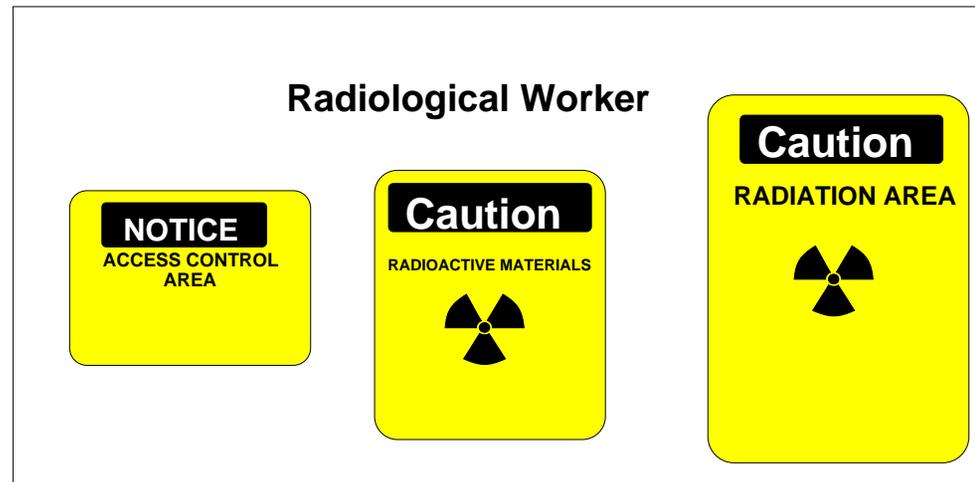
## Assessing Radiation Doses

**Designers should provide for anticipated dose risk by analysis of task and process.**



# General low-level dose-rate operations areas

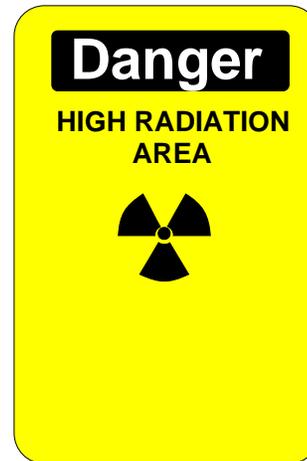
GERT/visitor, orientation or



107-5

## Access Control

**Process areas  
may be higher  
dose rate areas.**



107-6

**It is important  
to minimize  
multiple  
sources of  
dose.**

## **Controls in high-dose-rate areas may include:**

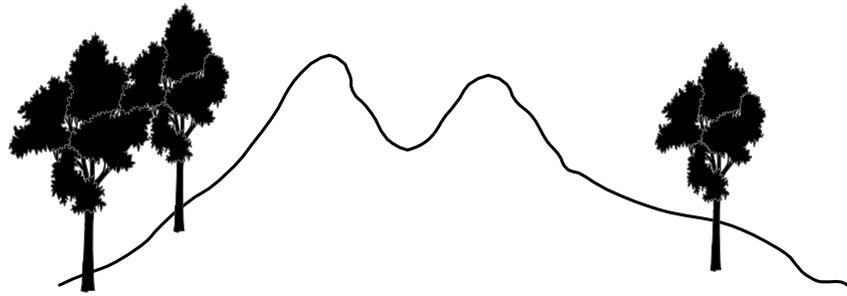
- **Remote operations of equipment and systems.**
- **Isolation of processes from general work areas.**

## **Building layout is an important factor in controlling personnel dose**

**Proper layout reduces casual or transient exposures to radiation fields by segregating heavily used corridors and work areas from areas of elevated dose rates and potential contamination.**

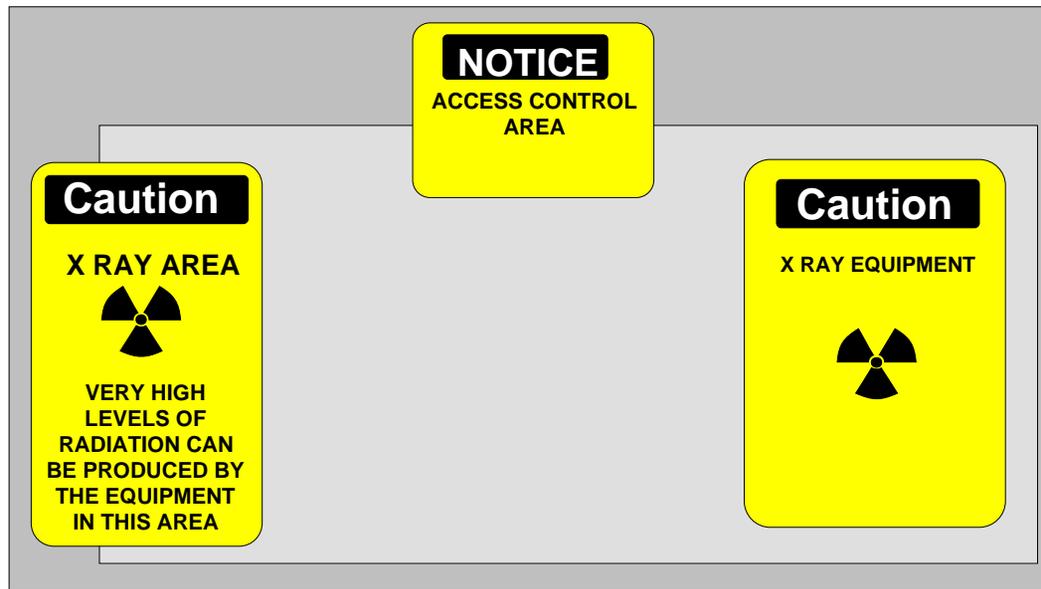


## Plan for eventual decontamination and decommissioning (D&D)



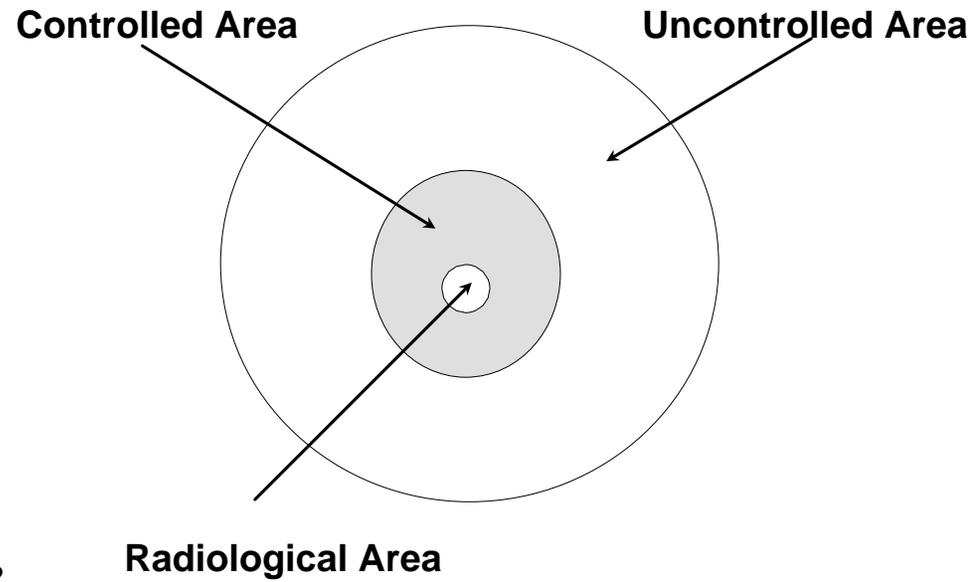
107-10

**A system of sequential areas can aid in control of personnel dose**



107-11

## General Access and Controlled Area are two major types of occupancy areas



## Traffic and Access

- **Locate frequently used pathways in low-dose rate areas.**
- **Ensure that doorways are wide enough and large enough.**
- **Radiological areas should be made as small as possible.**

107-13

## **Contamination Control Design**

**Contamination control measures  
may consist of --**

- **curbs,**
- **gutters, or**
- **other liquid controls.**

107-14

# **RADIOACTIVE WASTE**

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107-15

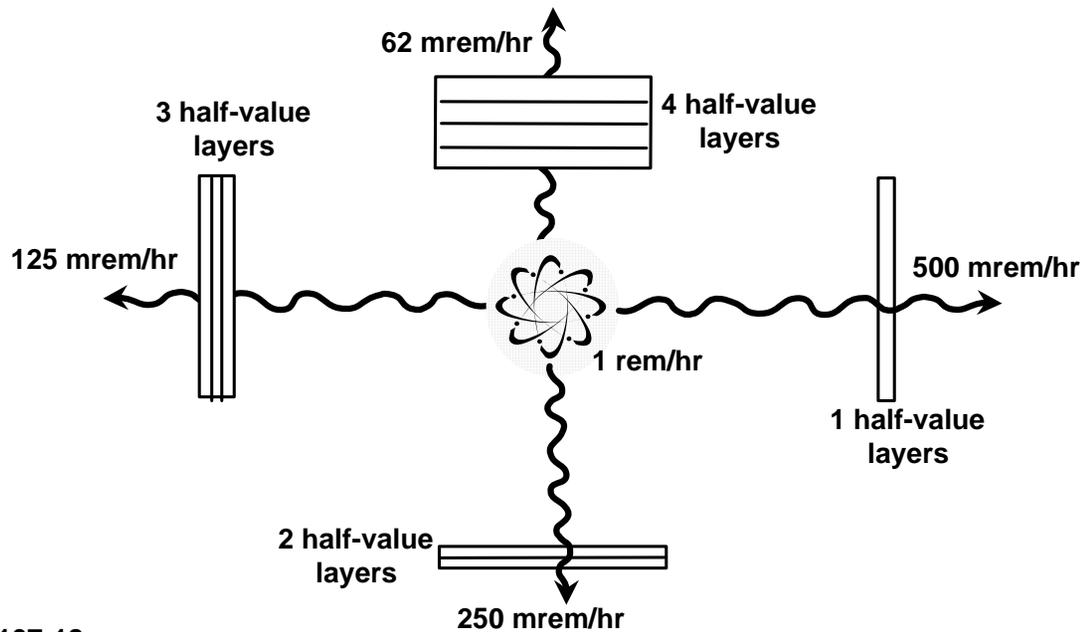
## **Location for the temporary storage of radioactive waste must be designed:**

- **Into the overall building plan.**
- **For each area where radioactive materials are handled.**

# **SHIELDING, PENETRATIONS, and ROUTING**

DOE-HDBK-1110-2008

## Obtain information on shielding from a specialist



## Penetrations and Routing

- **Have experts from all affected disciplines review a planned penetration before the hole is made.**
- **Don't route ducts and pipes containing radioactive material where people are located.**

107-19

# **Separation, Segregation, Placement, and Isolation**

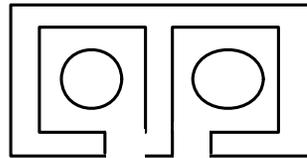
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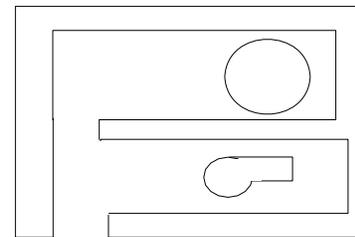
107-20

# Separation - by radioactivity or maintenance requirements

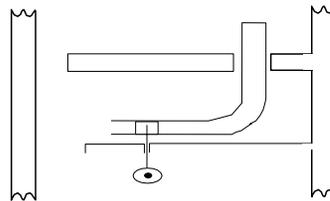
twin tanks



tank & pump

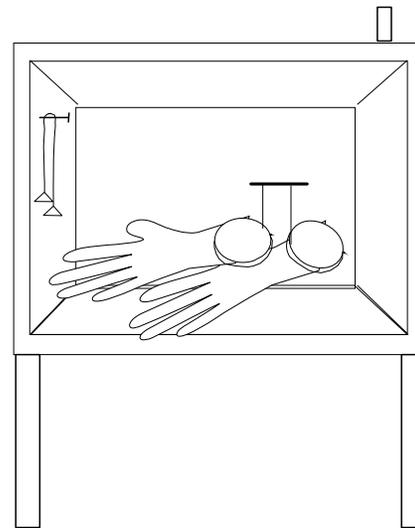


valve & reach rod



## Segregation of areas and systems by --

**Radioactivity,  
concentration, or  
potential for  
contamination.**



# Placement

**Place components with lower dose rates, higher access requirements, or more active characteristics nearest to the access point for the group. Place components with higher dose rates, lower access requirements, or more passive characteristics farthest from the access point for the group.**

## Isolation of equipment

- **Properly place isolation valves to minimize dead legs.**
- **Minimize pipe runs in valve aisles.**

# **Redundancy**

**Provide adequate redundancy and backup capability, especially in systems of high radioactivity content and safety systems. Provide appropriate cross-connections to achieve.**

# **Accessibility, Laydown, and Storage**

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107-26

# Human Factors

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107-27

## **Designs should address human factors such as:**

- **Vision**
- **Hearing**
- **Physical limitations**
- **Heat stress**

# Module 108

## ALARA DESIGN REVIEW

**An ALARA design review is a systematic review of the design and construction of equipment/facilities to ensure that ALARA considerations are evaluated, incorporated if reasonable, and documented for modification to existing and new facilities that involve the potential for exposure to ionizing radiation.**

108-1

**10 CFR 835.1001 requires that**

**“engineered controls and  
administrative controls  
shall be used for  
facilities and equipment  
to keep radiation doses  
in controlled areas  
ALARA.”**

## **The ALARA design review is conducted in five discrete phases:**

- **Dose assessment,**
- **Determination - Conduct or Not Conduct Review,**
- **Select reviewers,**
- **Selection of Criteria and Conduct of Review**
- **Documentation of the ALARA process.**

108-3

## **Perform dose estimates from the information gathered, including:**

- **Layouts and location diagrams;**
- **Number and types of workers;**
- **Nature of each task;**
- **Time spent by each worker per task;**
- **Paths to and from;**
- **Physical features; and**
- **Dose rates, wall thickness, etc.**

## **Revise dose estimates as more design information becomes available**

- **A walkdown of the installation with construction and radiological control personnel may be valuable at this time.**
- **Detailed dose information is needed for selection of design alternatives.**
- **The detailed dose assessment involves dose estimation for operation, maintenance, inspection, and installation of equipment.**

108-5

**After initial dose assessment - Should an ALARA design review be performed?**

**First issue --**

**Does the design change involve work on a radioactive or potentially radioactive system?**

## **The Second issue is -- Will this design change cause additional concerns?**

- **Create a new radiological area?**
  - **Create or increase routine maintenance, operations, or inspection?**
  - **Cause workers to exceed a threshold, such as 1 rem or greater?**
- 

**If any of these criteria are met, additional occupational dose will result and further review should be conducted.**

## **An ALARA design review need not be conducted**

- **If the answer to all 3 questions is "NO."**
- **If no radioactive or potentially radioactive components, systems or areas are involved.**
- **If there is one-for-one replacement of equipment or if the design does not present the practical opportunity to incorporate dose reduction features.**

108-8

## **ALARA design review team key personnel**

- **Design Team**
- **Contributor Group**
- **ALARA Review Coordinator**
- **Radiological Control and/or  
ALARA Representative(s)**

**ALARA Design Review is performed at each  
key stage of design or modification.**

## **Minimum objectives to be considered in ALARA reviews**

- **Protect the public and facility personnel from hazards**
  - **Normal operations**
  - **Anticipated operational occurrences**
  - **Design Basis Accidents**
- **Review the general facility layout.**
- **Verify that the ventilation system is adequate.**

## **Minimum objectives to be considered in ALARA reviews (cont'd.)**

- **Evaluate and confirm the adequacy of radiological control devices.**
- **Verify that shielding meets ALARA requirements.**
- **Assess the adequacy of planned radiation monitoring.**
- **Radiological requirements and ALARA considerations should be balanced.**

## **The design shall address all health hazards**

- **The release of hazardous materials under normal operating conditions and anticipated operational upset occurrences shall be less than release guideline values.**
- **Consideration shall be given to the frequency of occurrence and the effects.**

**Designs for new facilities and major modifications to existing facilities should be based on:**

- **Individual dose <500 mrem/yr.**
- **Discharges should not degrade ground water.**
- **Control of contamination by containment.**
- **Efficiency of maintenance, operations, decontamination and decommissioning.**

**Designs for new facilities and major modifications to existing facilities should be based on: (cont'd.)**

- **Components should be selected to minimize the buildup of radioactivity.**
- **Support facilities for donning and removal of protective clothing and for personnel contamination monitoring when required.**

## **The ALARA Design Review Checklist contains the following:**

- **Preliminary questions that serve to sort out which groups of questions in the main list are needed;**
- **Main checklist, a series of questions grouped by subject;**
- **Disposition sheet on which individual answers may be discussed and resolutions may be recorded.**

**An ALARA Design Review should be considered near the end of each stage**

**If the reviewer recognized any issues of potential radiological impact not covered by the checklist, these issues should be noted.**

**Also consider impact of "nonrad"  
additions on radiological items**

**Not only new or newly added  
features, but also existing  
features that might be affected  
must be addressed.**

108-17

**Optimization analysis is required  
and is presented in Module 110**

**Optimization includes costs  
of ALARA measures, dose  
savings, and intangible  
variables such as worker  
concerns, administrative  
concerns, etc.**

## **Documented ALARA review should contain**

- **Design documentation;**
- **Review approvals; and**
- **Copies of the report.**

# MODULE 109

## ALARA OPERATIONAL REVIEW

**An ALARA operational review is a systematic pre- and post-job review of high-dose activities to ensure that ALARA controls are planned, evaluated, implemented where reasonable, and documented.**

**10 CFR 835.1003 requires --**

**During routine operations, the combination of engineered and administrative controls shall provide that the occupational dose to general employees does not exceed the limits and that the ALARA process is used.**

**Reviews can be done when required by procedure or as requested.**

**An ALARA operational review should be performed for any of the following:**

- **Nonroutine jobs or operations in which any individual may receive a dose > 100 mrem or where there is uncertainty in the predicted dose.**
- **Routine jobs or operation in which an individual might receive > 300 mrem.**
- **Any job or operation in which the collective dose is expected to exceed the facility-specific trigger level.**

**An ALARA operational review should be performed for any of the following: (cont'd.)**

- Any job or operation in which any individual may exceed the administrative control level.
- Any job or operations in which the dose is greater than an ALARA goal.
- Any job or operation in which airborne levels may potentially exceed 10 percent of the DAC.

109-4

**The operational review is conducted in addition to the Radiological Work Permit (RWP)**

**A simplification of this process would be appropriate for small, uncomplicated operations. The operational review could support RWP preparation or the reviews.**

**Here is an aid (checklist) in performing RWP review; it includes:**

- **Pre-Job Planning section**
- **Pre-Job section**
- **Operational Review section**
- **Disposition sheet**

# **MODULE 110**

## **OPTIMIZATION ANALYSIS**

**"Optimization" may be defined as arriving at an optimal solution to a problem or selecting the best from among the available alternatives in accordance with a given analytical method.**

**10 CFR 835.1002 requires  
radiation exposure optimization**

**10 CFR 835 states, "Optimization  
methods shall be used to assure that  
occupational exposure is  
maintained ALARA in developing  
and justifying facility design and  
physical controls."**

# Optimization Guidance

- DOE Order 5400.5, Ch. 2, "Radiation Protection of the Public and the Environment"
- ICRP 55, "Optimization and Decision-Making in Radiological Protection"

110-3

## Optimization Guidance(cont.)

- **RadCon Standard Article 312**
  - **Minor activities**
  - **Major activities**
- **PNL-6577, "DOE, Health Physics Manual of Good Practices for Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA)"**

110-4

## **PNL-6577 addresses the minimum steps for cost-benefit analysis**

- **Identify all possible options.**
- **Estimate individual and collective dose.**
- **Identify cost for all viable options.**
- **Determine cost in dollars per person-rem avoided.**

**The purpose of an optimization analysis is to determine if the cost is justified**

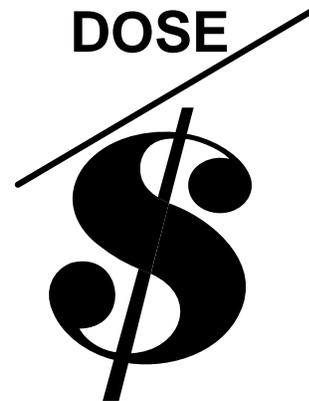
**This is in accordance with the idea of balancing dose reduction considerations against technological, social, operational, and economic considerations.**

## Determination of Alternatives

- **Informal analysis.**
- **Other considerations (status quo) is one alternative.**
- **Formal optimization analysis.**

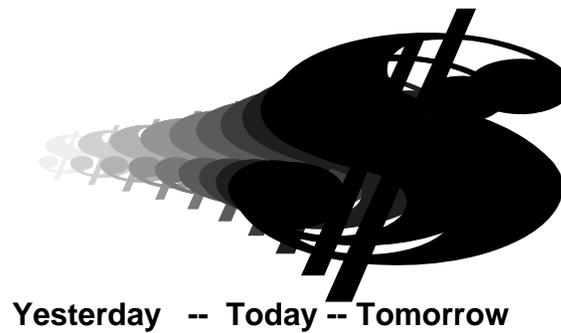
## **One analytical method is the Cost Benefit Analysis (CBA)**

**This is done like  
the traditional  
CBA, except that  
dose is considered  
as one of the cost  
factors.**

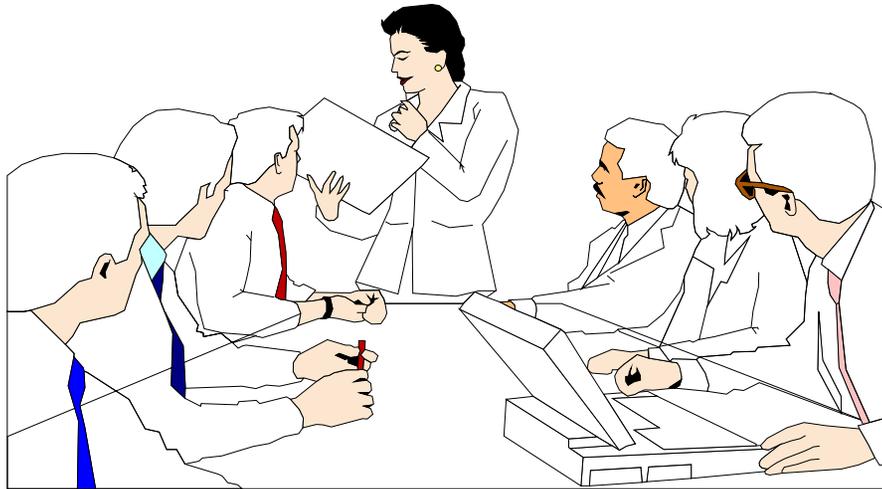


# Cost and savings must be estimated over the life of the new technique

In addition, inflation should be factored in.



## CBA should be done by the project/ operations engineer or designee



## **There are four major steps to the CBA**

- **Describe feature, measure and radiological aspects.**
- **Calculate costs.**
- **Determine the net benefit.**
- **Perform subjective factor analysis and/or sensitivity analysis.**