DOE/SR-~~8006, Vol~~ II

General Employee Orientation Training Course - Radiation Safety Instructor's Guide

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Prepared by
NUS Corporation

A.D. Holmes, DOE-SR Task Leader
P.O. Matthews, DOE-SR Task Manager

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U.S. Department of Energy

Facility Safety Division
Radiation Protection Branch
Savannah River Operations Office
Aiken, South Carolina

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DOE/SR--8006-Vol.2

LESSON TITLE: General Employee Orientation Training

DE90 005347

CONTACT HOURS: 4

INSTRUCTIONAL MATERIALS:

A. Instructor Materials

1. Overhead Projector
2. Transparencies and Erasable Transparency Marker

B. Student Materials

1. Student Handout
2. Pen or Pencil

LEARNING OBJECTIVES

1. Define the terms radiation and contamination. (2.4.1.1)

2. Describe ionization. (2.4.1.6)

3. State the basic units for exposure and exposure rate measurement. (2.4.1.5)

4. List three major sources of natural background radiation. (2.4.1.4)

5. Describe the biological hazard from ionizing radiation. (2.4.1.3.c)

6. Describe the difference between threshold and non-threshold biological effects from radiation exposure. (2.4.2.1)

7. Describe the possible biological effects from short term exposure to radiation at varying dose levels. (2.4.2.2)

8. Describe the possible biological effects from long term exposure to the whole body. (2.4.2.3)

9. Describe the possible effects of prenatal exposure on a human embryo or fetus. (2.4.2.5)

10. State the DOE whole body exposure limit for members of the general public. (2.4.3.2)

11. Describe the ALARA philosophy. (2.4.3.1)

12. Discuss how time, distance and shielding can be used to reduce radiation exposure. (2.4.5.1)

13. State the responsibilities of DOE and the operating contractor for development and maintenance of a radiation protection program. (2.4.3.13)

MASTER

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LEARNING OBJECTIVES (Continued)

14. Describe how radioactive materials are contained and controlled. (2.4.3.12)

15. State the four ways in which radioactive contamination can enter the body. (2.4.3.10)

16. Describe the colors, symbols and signs used to identify the boundaries of regulated areas. (2.4.3.6)

17. Describe how to identify areas controlled for radiation protection purposes that the general employee is not permitted to enter without an escort. (2.4.3.7)

18. State the purpose of a TLD and explain where it is worn on the body. (2.4.3.8.a)

19. Describe the methods used for monitoring for internal contamination. (2.4.3.11)

20. Discuss radiological situations that might require plant evacuation. (2.4.4.5)

21. Describe the planned protective actions for radiological emergencies. (2.4.4.7)

22. State the employee's responsibilities toward the radiation protection program. (2.4.3.14)

23. Identify the assigned shelter area for the individual's work group. (2.4.4.4)

24. Identify evacuation routes from the individual's work area. (2.4.4.6)

25. State how to recognize and respond to a radioactive spill. (2.4.4.8)

Content:	Instructor's Notes:
I. PURPOSE OF INSTRUCTION	TP-GEOT-1
A. Inform employees	
1. Radiological hazards in workplace	
2. How to minimize risk from radiological hazards to	
a. Self	
b. Fellow workers	
c. Public	
3. Rules related to radiation safety	
4. Individual worker responsibilities	
B. Objectives	TP-GEOT-2
II. RADIATION	
A. Definition	
1. Includes energy forms of light, radio waves, microwaves	
2. Commonly used to mean ionizing radiation	TP-GEOT-3
a. Ability to transfer energy to produce charged particles	2.4.1.1, 2.4.1.6
b. Energy form (gamma, x-ray)	
c. Energetic particle form (alpha, beta, neutron)	
d. Each type has different hazards	
(1) Due to different characteristics	
(2) Type identified on signs, surveys by HP	
B. Units of exposure, exposure rate measurement	TP-GEOT-4
1. rem for exposure	2.4.1.5
a. Other units used for specific types of radiation	
b. rem can be used for any type of radiation	
c. Measure of biological damage when radiation absorbed in body tissue	
2. rem/hr for exposure rate	

Content:

Instructor's Notes:

C. Sources

1. Cosmic
   a. Produced in outer space
   b. Component of natural background
2. Radioactive material — TP-GEOT-5
   a. Unstable atoms
   b. Called contamination if in undesirable location
   c. Can emit radiation in an attempt to become more stable
   d. Can emit radiation by fission
3. X-ray machines
4. Occur in nature and made by man -- every individual exposed
5. Natural background has always been present — TP-GEOT-6
   a. Cosmic is energetic particles from sun or deep in galaxy — 2.4.1.4
      (1) Earth's atmosphere protects us
      (2) Amount received depends on amount of air above
      (3) In U.S., on average, accounts for about 9% of natural background
   b. Radioactive material in soil present since earth formed
      (1) In U.S., on average, accounts for about 9% of natural background
   c. Radioactive material in air primarily result of radioactive material in soil
      (1) Radon gas released into air
      (2) Indoor exposure in U.S., on average, accounts for about 68% of natural background
   d. Natural radioactive materials in body
      (1) Primarily radioactive forms of potassium and lead from food, also radioactive carbon from CO_2 in air
      (2) In U.S., on average, accounts for about 14% of natural background

Content: Instructor's Notes:

6. Manmade through fission, artificial production of radiation and radioactive materials
   a. Fallout from nuclear weapons
      (1) Average additional exposure <0.5% of natural background
   b. Production, utilization of fissionable material used in reactors and weapons
      (1) Activities closely regulated, controlled to limit exposure to public to very small amount
      (2) In CSRA additional exposure is primarily from SRP and Vogtle
          • Less than 0.1% of natural background
          • From release of radioactive materials
   c. Medical practice uses for diagnosis and treatment
      (1) X-rays
      (2) Administration of radioactive materials
      (3) Average additional exposures of 18% of natural background
   d. Miscellaneous manmade sources
      (1) Consumer products containing radioactive material
      (2) Fly ash from coal generating plants contains traces of naturally occurring radioactive material
      (3) Average additional exposure 3% of natural background

D. Interaction with matter

1. Rays, particles of ionizing radiation different from other forms of energy
   a. Each ray or particle has enough energy to cause chemical changes in material in which absorbed
   b. Transfers energy to atoms in material in path

Content:

Instructor's Notes:

c. If transferred energy greater than energy bonding orbital electron then electron may be ejected
   (1) Called ionization
   (2) Ejected electron is negative ion
   (3) Remaining nucleus and electrons is positive ion

TP-GEOT-7

2. Molecules chemically bonded by atoms sharing electrons
3. Ionization
   a. Can split molecule
   b. Can cause recombination with different atom or molecule
   c. Directly, indirectly disrupts, interferes with normal chemical activity

E. Biological damage

2.4.1.3.C
TP-GEOT-8

1. Body made up of organs
2. Organs made up of tissues
3. Tissues made up of cells
4. Cells made up of molecules
5. Molecule altered by ionization may not be able to perform normal functions
   a. Chemically unstable
   b. Will attempt to bond again to become stable
   c. New molecule may be different than original
   d. Disrupts normal chemical activity in cell
6. Cell can recognize, repair or replace damaged molecules
7. If cell performs function before it is repaired, it may perform incorrectly, incompletely
8. The higher the chemical activity in the cell, the higher the chance of chemical disruption (i.e., high radiosensitivity)
9. Developing embryo most sensitive
10. Observable effects depend on damage rate and total damage
    a. As long as repair/replacement rate exceeds damage rate, no observable effect

Content: Instructor's Notes:

b. Other cells take over function until repair complete
c. If excessive number damaged at one time body may replace
d. Population decrease if repair rate + replacement rate < damage rate
e. No observable injury unless population too low to perform function
f. Large exposure over short time produces observable effects because damage rate exceeds repair, replacement rate
g. Small exposure over long time does not produce observable effects because repair, replacement rate exceeds damage rate

11. Some cell damage not repaired
a. Damage not recognized by repair mechanism
b. Repair mechanism damaged
c. Cumulative damage increases probability of abnormalities

III. BIOLOGICAL EFFECTS FROM RADIATION EXPOSURE

A. Threshold effects not known to occur unless a minimum damage occurs in less time than can be repaired — TP-GEOT-9 2.4.2.1

1. Can be prevented by ensuring exposure doesn't exceed threshold
2. Include
a. Radiation sickness, death — 2.4.2.2
b. Sterility
c. Loss of hair
d. Reddening of skin
e. Benign tumors
f. Cataracts
3. DOE limits are established to prevent effects during normal operations

Content:	Instructor's Notes:
B. Non-threshold effects have no minimum damage below which effect known not to occur	TP-GEOT-10
	2.4.2.3
1. Cannot be prevented without completely eliminating exposure	
2. Include cancer, genetic defects in offspring, birth defects	
3. Probability of occurrence minimized by maintaining exposures ALARA	
C. Embryo/fetus more sensitive than adults	TP-GEOT-11
1. First four months most critical	2.4.2.5
2. Increases risk of small head, childhood cancer, mental retardation	
3. Effects caused by many hazards	
4. DOE limits exposure to pregnant occupational workers to minimize probability	
IV. POLICIES AND PROCEDURES	
A. EPA Guidance to Federal Agencies	TP-GEOT-12
1. Considers recommendations of national, international experts	
2. Most recent guidance recommends	
a. No occupational radiation exposure without overall benefit from activity	
b. No exposure acceptable without regard to reason for it	
c. ALARA should be general practice	
3. DOE policies, procedures implement	
a. Keep all exposures within limits	
b. Keep all exposures ALARA	

Content:	Instructor's Notes:
B. DOE Exposure Limits	
1. 0.1 rem/year to members of general public from DOE activities	TP-GEOT-13
a. Prevents observable effects from short term exposure	2.4.3.2
b. Limits probability of effects from long term exposure to level equivalent to risks normally accepted by public as not of concern	TP-GEOT-14
(1) All risks equated to average lost days of life expectancy	
(2) Risk estimates account for	
(a) Treatability	
(b) When in lifespan effects may occur	
2. Higher limit for radiation workers of 5 rem/year	
a. Radiation worker if job assignment requires	
(1) Working on, with or in proximity to radiation producing machines, radioactive materials	
(2) Potential to be routinely exposed above general public limit	
b. Allowed because radiation worker receives more benefit from activity than member of public	
c. Based on controlling risk to level comparable to "safe" industries	TP-GEOT-15
d. Additional training required before higher limit applied	
(1) Prior to or concurrent with assignment as radiation worker	
(2) Covers rules, procedures, techniques to minimize exposure	

Content:	Instructor's Notes:
C. ALARA	TP-GEOT-16
1. Estimated probabilities for effects from long term exposure assume no threshold	
2. DOE policy to maintain all exposures to employees, contractors, general public ALARA	2.4.3.1
a. For individuals to minimize cancer risk	
b. For collective worker population to minimize risk of genetic defects in offspring	
3. "Reasonably" includes technical, economic, practical considerations	
D. Exposure Control	
1. Basic techniques to reduce exposure are	TP-GEOT-17
a. Minimize time near source	2.4.5.1
b. Maximize distance from source	
c. Maximize shielding to source	
2. Many basic techniques implemented by DOE	
3. DOE required to furnish conditions free of recognized hazards	2.4.3.13
a. DOE policy is that primary means to maintain radiation exposure ALARA is design	
b. Physical controls supplemented by administrative controls	
c. At SRP, operating contractor delegated responsibility to develop, implement safety rules	
(1) Health Protection responsible for assisting all who enter to comply	
4. Facility design and administrative practices	
a. Time minimized by designing processes, facilities for efficient operation	
b. Major radiation sources shielded	

Content:	Instructor's Notes:
c. Distance also maximized by design, supplemented by admin and procedural controls	
d. Processes, facilities designed to contain sources	2.4.3.12
(1) Radioactive materials processed in enclosed systems	TP-GEOT-18
(2) Radioactive materials packaged in leak tight containers	
(3) Buildings have special ventilation	
(4) All personnel, equipment monitored for contamination	
(5) Important because loose contamination on surfaces, in air could enter human body	2.4.3.10
• Inhalation	
• Ingestion	
• Open wounds and sores	
• Absorption through unbroken skin	
e. Access to areas where individual could exceed 100 mrem/yr controlled	2.4.3.6
(1) Fences, barricades, walls, other physical means	
(2) Posted as a regulated or controlled area	TP-GEOT-19
• Additional signs used inside regulated or controlled areas	
• Black or magenta letters, symbols on yellow background	
• Trifoil	
• No entry unless trained as rad worker or escorted by rad worker	2.4.3.7
f. Containers of radioactive material being transported between regulated or controlled areas identified	
(1) Vehicle labelled with yellow and black or magenta sign with trifoil	TP-GEOT-20
• Regulated use	
• On dashboard or driver's door	
• Some vehicles have signs on all sides	
(2) Package may be part of vehicle (tank truck)	
(3) Most common package is yellow metal boxes of low level radioactive waste to burial ground	TP-GEOT-21

Content:	Instructor's Notes:
5. Personnel monitoring for external radiation exposure	
a. To ensure controls for limiting exposure in regulated or controlled areas are effective	
b. All who enter regulated or controlled areas	
c. Permanently assigned to radiation workers	
d. Visitor dosimetry assigned to general employees if need to enter regulated or controlled area	
e. TLD is primary dosimetry device	TP-GEOT-22
(1) Crystals absorb, retain energy from radiation	
(2) Emits light proportional to radiation absorbed when heated	
(3) Light output measured by separate instrument, equated to radiation exposure	
f. Whole body TLD's	2.4.3.8.a
(1) Required to be worn	
(a) By all who enter regulated or controlled areas	
(b) On outside of personal clothing	
(c) Between waist and shoulders	
(2) Exercise care in handling	
(a) Don't subject to high heat, moisture	
(b) Don't poke objects in beta window	
(c) Don't remove from case	
(3) To obtain visitor TLD	
(a) Available in 703-46A lobby	
(b) Both general employee and escort must sign form	
(c) Return at end of day	
• Additional green label TLD's monitor background at rack	
• Green label TLD reading subtracted from Individual TLD's -- if lower background at home than in 703-46A, dose underestimated	

Content:	Instructor's Notes:
6. Personnel monitoring for internal radiation exposure	2.4.3.11
a. Whole body and chest counters	TP-GEOT-23
(1) Measure amount of radioactive material inside body	
(2) Measurements used to calculate exposure from internally deposited radioactive material	
(3) Baseline required before first entry to regulated or controlled area	
(a) If have worked at other facilities where internal contamination possible	
(b) To differentiate between SR and previous exposure	
(4) Periodic routine	
(a) Frequency based on work assignment	
(b) To detect long term accumulation of very small quantities	
b. Urine/feces/blood samples	
(1) Analyzed in laboratory	
(2) Urine sample used to measure isotopes not readily measured by chest or whole body counter	
(a) Baseline required if have worked at other facilities	
(b) Periodic routine required for all who enter regulated or controlled areas	
(c) Routinely performed for those working where tritium present	
(d) Only dosimetry available for tritium	
(3) Collection	
(a) Urine/feces by individual -- instructions and containers provided	TP-GEOT-24
(b) Blood collected by medical	
7. Emergency planning	
a. Accident can occur even though facilities designed, operated safely	
b. DOE policy to plan for control, mitigation, management of credible emergencies even though unlikely to occur	

Content:	Instructor's Notes:
c. Emergency defined as situation, condition that could endanger personnel, facilities, environment	
d. Nuclear emergencies	2.4.4.5
(1) Include unanticipated exposure to radiation, release of radioactive material to environment	
(2) Could be caused by failed equipment, reactor accident or improper experimentation procedures	
e. Non-nuclear emergencies could be from	
(1) Fire	
(2) Explosion	
(3) Natural events (tornado, earthquake, hurricane, etc.)	
(4) Civil disturbance	
(5) Hazardous materials	
(6) Personnel injury of illness	
f. Emergencies classified according to risk to offsite personnel	TP-GEOT-25
(1) Unusual Event has no potential for significant offsite release of radioactive material	
(2) Alert is potential reduction of safety of facility	
(a) Limited offsite releases may occur	
(b) Need for offsite protective actions unlikely	
(3) Site Emergency involves actual or potential failure of facility safety systems	
(a) Offsite releases likely or occurring	
(b) Need for offsite protective actions unlikely	
(4) General Emergency involves actual or imminent failure of safety systems	
(a) Offsite releases occurring or expected to occur	
(b) Offsite protective actions necessary	
g. Announced over PA system if declared, supplemented by alarms in some areas	
h. All postulated accidents that could cause significant radiation exposure outside process area involve release of large amount of radioactive material in plume	

Content:	Instructor's Notes:
i. Plans have 2 major protective actions for plume	TP-GEOT-26
(1) Evacuation uses distance -- most effective if time to complete before release	2.4.4.7
(2) Sheltering uses shielding, isolates airborne activity so it won't be inhaled	
(a) Most effective if	
• Release already occurring	
• Release expected before evacuation could be completed	
(b) May also be used if other risks exceed risk from radiation exposure (tornado, etc.)	
V. INDIVIDUAL RESPONSIBILITIES	2.4.3.14
A. OSHA Act of 1970 assigns responsibilities to individual workers as well as to DOE	TP-GEOT-27
1. Comply with all standards, rules established to protect worker health and safety	
2. Includes operating contractor rules when in their areas	
B. Stay out of areas posted as Regulated or Controlled Areas unless	
1. Trained as radiation worker	
2. Escorted by someone trained as radiation worker	
C. Familiarize self with emergency procedures; know alarms, shelter, evacuation route -- ask supervisor if not sure	
1. Shelter	TP-GEOT-28
a. Slow warble alarm	2.4.4.4
b. For DOE employees in 700-A area including trailers	
(1) Move to first floor inside hallways in 703-A and 703-41A (evacuate trailers)	
(2) Stay away from windows and outside doors	
(3) Follow directions from office/division EP Coordinator or over PA	

Content:

Instructor's Notes:

2. Evacuation
   a. Fast warble alarm
   b. Go home using normal routes unless instructed otherwise
      (1) Use normal exits to parking lot
      (2) If no transportation
         (a) Notify office/division EP Coordinator
         (b) Wait in front of 703-A for further instructions

TP-GEOT-29
2.4.4.6

D. Look for, respond to incidents
   1. Incidents that are only likely to occur in regulated or controlled areas covered in radiation worker training -- follow escort instructions if incident occurs while visiting
   2. Transportation incident is only type likely to occur outside regulated or controlled areas
      a. Indicated by
         (1) Container leaking, spilling contents
         (2) Container falling from vehicle
         (3) Container, vehicle left unattended outside regulated or controlled area
      b. Notify or have someone notify Health Protection
      c. Stay clear
      d. Warn others to stay clear

TP-GEOT-27
2.4.4.8

E. If visiting regulated or controlled area area with an escort
   1. Obtain, properly wear dosimetry per procedures or escort
   2. Minimize own exposure
      a. Minimize time in area
      b. Maximize distance to sources
   3. Obey instructions from your escort
   4. To ensure that exposure limit is not exceeded, do not enter: Radiation Area, High Radiation Area, Very High Radiation Area, Contamination Area, or Airborne Radioactivity Area (If entry is required obtain specific permission from the area Health Protection Supervision - or - attend RWT

F. Additional information available from DOESR Health Protection Staff

DOE-SR GENERAL EMPLOYEE ORIENTATION TRAINING

LIST OF TRANSPARENCIES

TP-GEOT-1	Introduction
TP-GEOT-2	Objectives
TP-GEOT-3	Non-Ionizing and Ionizing Radiation
TP-GEOT-4	Radiation Exposure Units of Measurement
TP-GEOT-5	Basic Terms
TP-GEOT-6	Sources of Radiation Exposure
TP-GEOT-7	Ionization (Same as Figure 1 in Student Handbook)
TP-GEOT-8	Biological Structure of the Human Body (Same as Figure 2 in Student Handbook)
TP-GEOT-9	Possible Threshold Effects from Radiation Exposure
TP-GEOT-10	Possible Non-Threshold Effects from Radiation Exposure
TP-GEOT-11	Risks to the Unborn from Prenatal Exposure to Hazards
TP-GEOT-12	EPA Guidance to Federal Agencies
TP-GEOT-13	DOE-SR Radiation Exposure Restrictions
TP-GEOT-14	Risk Comparison -- Long Term Radiation Exposure vs. Other Common Risk Factors
TP-GEOT-15	Risk Comparison -- Work Involving Long Term Radiation Exposure vs. Common Occupations
TP-GEOT-16	The ALARA Concept
TP-GEOT-17	Basic Radiation Exposure Reduction Techniques
TP-GEOT-18	Control of Exposure to Contamination and Radiation
TP-GEOT-19	Picture of Regulated and Controlled Area Signs (Same as TP-RWT-27)
TP-GEOT-20	Picture of Regulated Use Vehicle
TP-GEOT-21	Picture of Open Truck Transporting Yellow B-25 Boxes
TP-GEOT-22	Picture Showing an SRP TLD Badge Properly Worn (Same as TP-RWT-33)
TP-GEOT-23	Picture of Person Being Counted in Whole Body Counter (Same as TP-RWT-64)
TP-GEOT-24	Picture of Urine Containers at a Typical Bioassay Station (Same as TP-RWT-65)
TP-GEOT-25	Emergency Classifications
TP-GEOT-26	Protective Actions
TP-GEOT-27	Individual Responsibilities
TP-GEOT-28	Shelter Protection
TP-GEOT-29	Evacuation

Inform employees of:

- Radiological hazards in the workplace
- How to minimize risk from radiological hazards
- Rules related to radiation safety
- Individual worker responsibilities

Objectives

- Inform employees of important information that will be presented in this orientation program
- Objectives are contained in the student handbook
- Employee has learned the important information when they can answer all of the objectives

Non-Ionizing and Ionizing Radiation

Non-ionizing radiation can cause the rate of chemical changes to increase or decrease but, does not have sufficient energy to produce charged particles

- **In energy forms such as light, radio waves, and microwaves**

Ionizing radiation has sufficient energy to produce charged particles which can cause different chemical changes in living tissue

- **In an energy form such as gamma rays and x-rays, or**
- **In an energetic particle form such as alpha, beta, and neutron**

Radiation Exposure Units of Measurement

Unit	Abbreviation	Meaning
rem	rem	Basic unit for measuring radiation exposure
rem/hour	rem/hr	Basic unit for measuring radiation exposure rate
millirem	mrem	Commonly used unit for measuring radiation exposure (1/1,000 rem)
millirem/hour	mrem/hr	Commonly used unit for measuring radiation exposure rate (1/1,000 rem/hour)

Basic Terms

Radiation - Ionizing radiation in the form of energy (gamma or X-ray) or energetic particles (alpha, beta, or neutron)

Radioactive Material - Substance containing unstable atoms that emit radiation

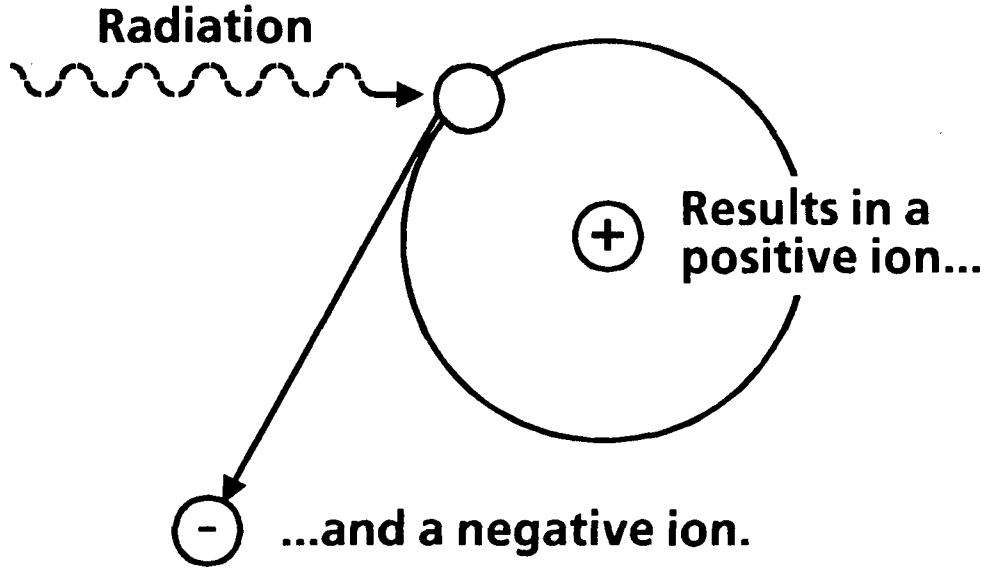
Contamination - Radioactive material that is in an undesirable location

SOURCES OF RADIATION EXPOSURE
In the vicinity of the Savannah River Site

Source of Exposure	Dose to Average Individual (mrem/yr)
Natural Background Radiation	
Cosmic Radiation	28
Radioactive Material in the Soil	28
Radioactive Material in the Air	200
Radioactive Material in the Body	39
Manmade Radiation	
Nuclear Weapons Testing	<1
Nuclear Facilities (other than SRS)	<0.1
SRS Environmental Releases (1988)	0.2
Medical Applications	53
Consumer and Industrial Products	10
Total	< 360

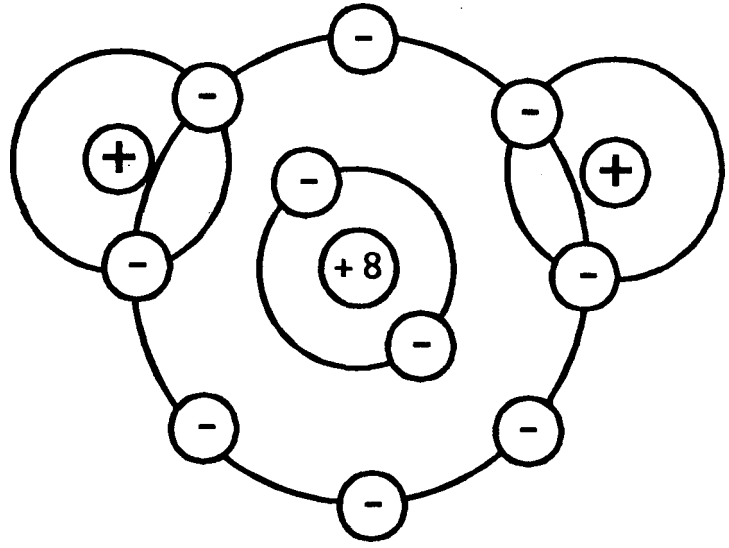
Ionization

Ionization of an atom...



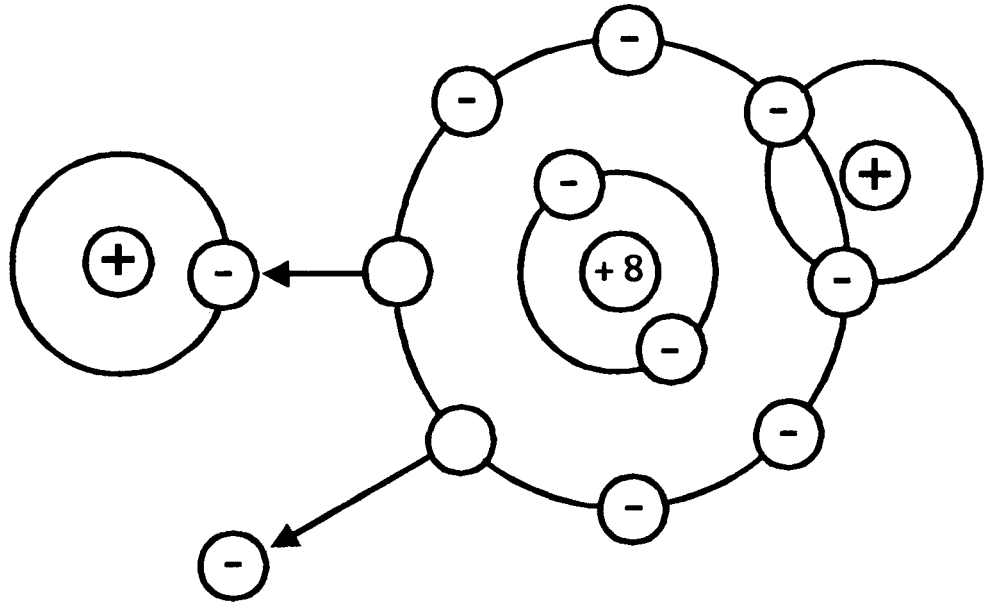
Ionization

Atoms share electrons to form molecules.



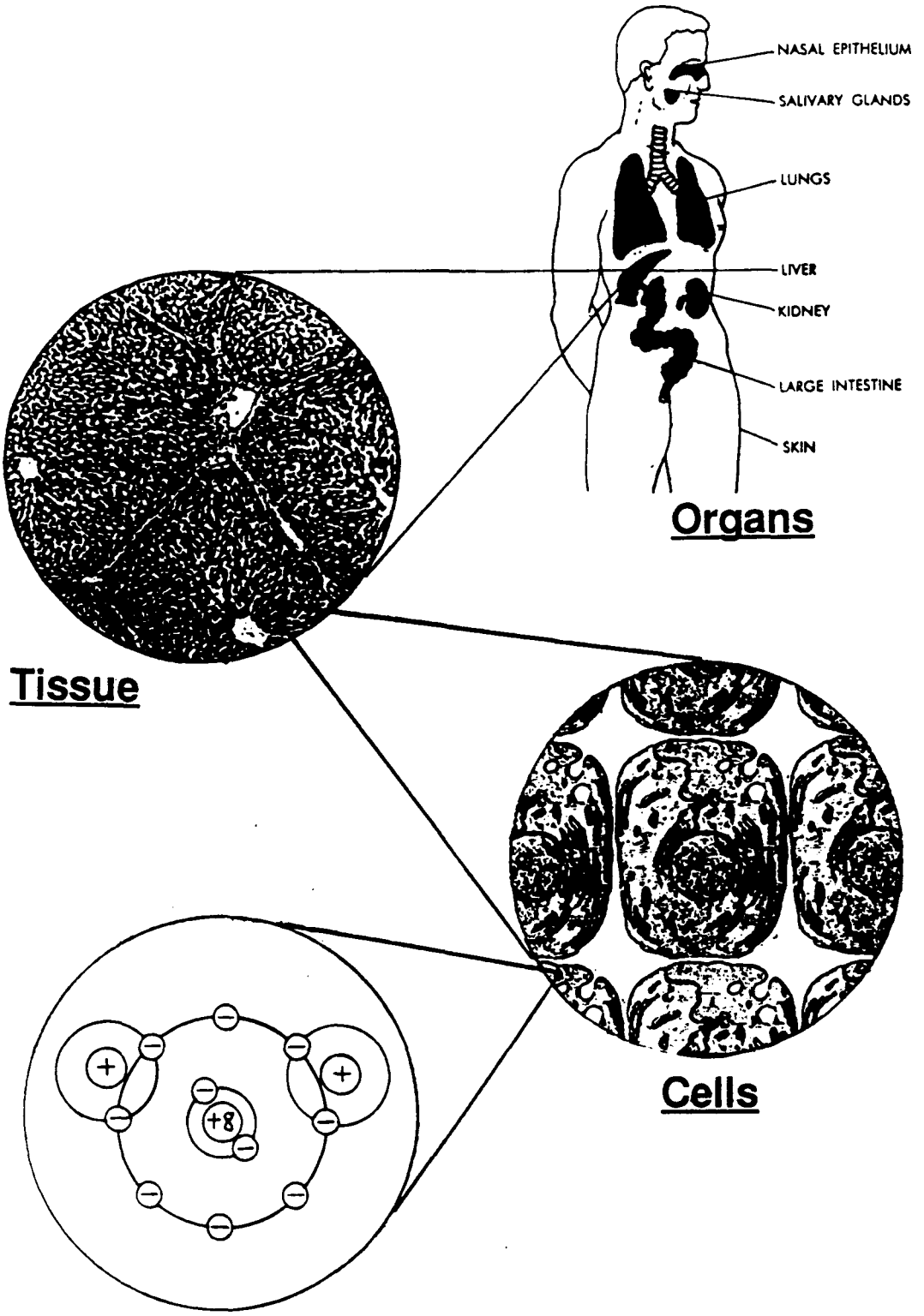
Ionization

If an ejected electron was shared by two atoms, the molecule may split apart...



...or may recombine with another atom or molecule.

Biological Structure of the Human Body



Possible Threshold Effects from Radiation Exposure

- Radiation sickness and death
- Temporary or permanent sterility
- Loss of hair
- Reddening of the skin
- Benign tumors
- Cataracts

DOE limits exposure to radiation at a sufficiently low level to positively prevent any of these effects from occuring during normal operation of all facilities.

Possible Non-Threshold Effects from Radiation Exposure

Based on extensive studies, it is conservative to assume that there may be a:

- **Small probability of genetic defects in offspring**
- **Small probability of cancer in exposed individual**
- **Small probability of birth defects from exposure during pregnancy**

DOE limits exposure to radiation and encourages that exposures be kept as low as is reasonably achievable in order to minimize the probability of any of these effects occuring to a level that is equivalent to working in any other safe industry.

Risk to the Unborn from Prenatal Exposure to Hazards

- Childhood cancer (Fatal)
- Small head size at birth
- Mental retardation

These effects are caused by many hazards in our environment. DOE limits radiation exposure to declared pregnant female occupational workers in order to minimize the probability of any adverse effects to the unborn child.

EPA Guidance to Federal Agencies

- There should not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure.
- No exposure is acceptable without regard to the reason for permitting it.
- It should be general practice to maintain exposure to radiation as-low-as-reasonably achievable below limiting values.

DOE-SR Radiation Exposure Restrictions

Employees and visitors who have not attended and passed radiation worker training	100 mrem
Radiation workers who have passed training	5000 mrem

Risk Comparison - Long-Term Radiation Exposure vs. Other Common Risk Factors

Estimated Loss of Life Expectancy from Health Risks

Health Risk	Estimates of Days of Life Expectancy Lost, Average	
Smoking 20 cigarettes/day	2,370	(6.5 years)
Overweight by 20%	985	(2.7 years)
All accidents combined	435	(1.2 years)
Auto accidents	200	
Alcohol consumption (U.S. average)	130	
Home accidents	95	
Drowning	41	
Natural background radiation, calculated	8	
Medical diagnostic x-rays (U.S. average), calculated	6	
All catastrophes (earthquakes, etc.)	3.5	
One rem of radiation exposure, calculated (industry average for higher exposure job categories is 0.65 rem/year)	1	
100 millirem each year for 50 years, calculated	5	

Risk Comparison - Work Involving Long-Term Radiation Exposure vs. Common Occupations

Estimated Loss of Life Expectancy form Industrial Hazards

Industry Type	Estimates of Days of Life Expectancy Lost, Average
All industry	74
Trade	30
Manufacturing	43
Service	47
Government	55
Transportation and utilities	164
Agriculture	277
Construction	302
Mining and quarrying	328
Radiation accidents, death from exposure	<1
Radiation exposure of 0.65 rem per year (industry average) for 30 years, calculated	20
Radiation exposure of 5 rem per year for 50 years	250
Industrial accidents at nuclear facilities (nonradiation)	58

The ALARA Concept

Radiation exposure is required to be maintained As-Low-As-Reasonably-Achievable:

Minimizing individual exposure minimizes the risk to the individual of getting cancer

Minimizing collective exposure minimizes the risk of birth defects in the offspring of the collective population

"Reasonably"

Proposed changes to reduce radiation exposure must consider:

- **Technical feasibility**
- **Cost**
- **Practicality**

Basic Radiation Exposure Reduction Techniques

- Time
- Distance
- Shielding

Control of Exposure to Contamination and Radiation

Processes and facilities are designed to contain contamination and sources of radiation:

- **Radiation materials are processed in enclosed systems**
- **Radioactive materials are packaged in leak tight containers**
- **Buildings have special ventilation**
- **All personnel and equipment are monitored for contamination**

Emergency Classifications

- Unusual Event
- Alert
- Site Emergency
- General Emergency

Protective Actions

- Evacuation
  - Uses distance to reduce radiation exposure
  - Provides greater protection than sheltering if completed before a radioactive release occurs
- Sheltering
  - Uses shielding and isolation to reduce radiation exposure
  - Provides greater protection than evacuation if:
    - Radiation release already occuring
    - Insufficient time to complete evacuation before a radioactive release is expected to occur
    - Risks from evacuation exceed risks from projected radiation exposure in shelter

Individual Responsibilities

- Comply with all rules established to ensure worker safety
  - Includes rules and procedures established by operating contractor for areas for which they are custodian
- Unless escorted, stay out of areas posted as a "REGULATED AREA" or "Controlled Area"
- Familiarize yourself with emergency procedures
  - Know your assigned shelter
  - Know the evacuation route from your assigned work area
- Be alert for and respond to radiological incidents
- If visiting regulated or controlled areas with an escort:
  - Obtain and wear dosimetry
  - Minimize your own radiation exposure
  - Obey instructions from your escort
  - Do not enter areas posted as a "Radiation Area," "High Radiation Area," "Very High Radiation Area," "Contamination Area," or "Airborne Radioactivity Area"

Shelter Protection

- Slow Warble Alarm
- DOE employees move to first floor interior hallway in 703-A or 703-41A (trailers must be evacuated) and await further instructions
- Stay away from windows and outside doors
- Follow the division/office Emergency Preparedness Coordinator's instructions and directions given over the public address system

Evacuation

- Fast Warble Alarm
- Evacuate work area using normal exit routes to your vehicle or carpool location in 3/700 parking lots
- DOE employees without transportation should notify their division/office Emergency Preparedness Coordinator and wait in front of 703-A building entrance for further instructions
- Follow the division/office Emergency Preparedness Coordinator's instructions and directions given over the public address system
- Leave and proceed home using normal routes unless instructed differently