Basic Radiation Training

Emergency Workers and Personnel & Equipment Monitors

State of Alabama
Office of Radiation Control
Alabama Department of Public Health
334.206-5412

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Nuclear Power Plants

- Alabama: There are two active nuclear power plants
- Training and Equipment
- 10-mile EPZ
- Browns Ferry: There are four risk counties and one host county
- Joseph M. Farley: There are two risk counties
Radiological Emergency Preparedness (REP) Plan

• Plan for OFF-SITE emergency response & recovery

• Utility is responsible for ON-SITE emergency response & recovery
Emergency Classification Levels

- Notification of Unusual Event
- Alert
- Site Area Emergency
- General Emergency
Radiation

Radiation is energy that travels in the form of waves or high-speed particles. It occurs naturally in sunlight and sound waves. Man-made radiation is used in X-rays, nuclear weapons, nuclear power plants, and cancer treatment.
REM (Roentgen Equivalent in Man)

- A unit of radiation dose equivalent used to measure the amount of damage to human tissue caused by all types of ionizing radiation

1 R = 1 Rad = 1 Rem

1000 mR = 1 R
Average Annual Radiation Exposure

- 620 mR/yr
- ~310 mR from natural radiation
- ~310 mR from man-made radiation
- <1 mR from nuclear power generation
Radioactive Material in Alabama

- Nuclear Power Plants
- Medical Uses
- Industrial Uses
- Research
- Naturally Occurring Radioactive Material (NORM)
- Waste Isolation Pilot Project (WIPP)
Two Types of Radiation

- **NON-IONIZING**: Radio and TV Waves, Infra-Red, Microwaves, Ultra-Violet
- **IONIZING**: Alpha Particles, Beta Particles, Gamma Rays, X-rays
Ionizing Radiation
Four Types of Ionizing Radiation
ALARA

As Low As Reasonably Achievable
Controlling Exposure

There are three basic considerations for protecting yourself from radiation:

- Time
- Distance
- Shielding
Protection from Radiation-Time

Less time in a radiation area = Less radiation exposure
Protection from Radiation-Distance

Greater the distance to ionizing radiation = Less radiation exposure

• Double distance = $\frac{1}{4}$ dose
• Triple distance = $\frac{1}{9}$th dose.
Protection from Radiation-Shielding

Thicker/Denser Material = Less radiation exposure
Time, Distance & Shielding
Exposure, Contamination & Decontamination

- Exposure
- Contamination
- Decontamination
Radiation Pathways

Ingestion

Inhalation

Absorption
Avoid Radioactive Contamination

Do not:
- Eat
- Drink
- Smoke
- Chew
- ChapStick
- Make-Up

Use PPE while on the scene of an incident involving radioactive material.
Contaminated Injured

In all cases, the treatment of an injury takes priority over decontamination.
Radiological Basics
Biological Effects of Radiation

• **Acute Effects**
  Nausea, Vomiting, Diarrhea, Hair Loss, Infection, Death

• **Chronic Effects**
  Reduced Fertility, Cataracts, Leukemia, Other Cancers, Life Shortening, Genetics effects
Biological Effects
Radiation & Our Five Senses

- We are aware of our environment through our five senses

- You must rely on instruments to detect the presence of radiation
KI (Potassium Iodide)

• Thyroid Blocking Agent

• Fills the thyroid gland with non-radioactive iodine

• Helps radioactive iodine from being absorbed into the thyroid

• Adult dosage 130 mg/day
Pocket Dosimeters

- Look through the dosimeter toward a light source
Radiation Exposure

• Dosimeter = Odometer

• Accumulated Exposure
CDV 750 Dosimeter Charger

- Clamp
- Clamp Trigger
- Discharge Button
- Generator Lever
Thermoluminescent Dosimeter

- Records radiation dose for legal/permanent exposure records
- Results not immediately available

![Thermoluminescent Dosimeter Image]

Lithium Fluoride Chips
Placement of the TLD & Pocket Dosimeter

TLD

Pencil/Pocket
TEDE
(Total Effective Dose Equivalent)

• Total Dose = External + Internal = 2 x External Dose

• TEDE = 2 x Pocket Dosimeter Reading
Radiation Dosage Limits for Emergency Workers

<table>
<thead>
<tr>
<th>Protecting Property, Patrolling Evacuated Areas, and Manning Check Points</th>
<th>TEDE</th>
<th>Dosimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek Relief</td>
<td>200 mrem</td>
<td>100 mR</td>
</tr>
<tr>
<td>Daily Maximum</td>
<td>1 rem</td>
<td>500 mR</td>
</tr>
<tr>
<td>MAXIMUM for ACCIDENT</td>
<td>5 rem</td>
<td>2.5 R</td>
</tr>
</tbody>
</table>

In addition to the above individual limits, all emergency workers are advised to make a reasonable effort to limit their total dose, while at the same time accomplishing their emergency responsibilities.

Alabama Radiation Control
Additional Radiation Dosage Limits for Emergency Workers

Additional Radiation Dosage Limits for Emergency Workers

<table>
<thead>
<tr>
<th></th>
<th>TEDE</th>
<th>Dosimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Saving</td>
<td>25 rem</td>
<td>12.5 R</td>
</tr>
<tr>
<td>Evacuating Known Residents</td>
<td>10 rem</td>
<td>5 R</td>
</tr>
<tr>
<td>Fighting Residence Fires</td>
<td>10 rem</td>
<td>5 R</td>
</tr>
</tbody>
</table>

- Read dosimeters and record every 15-30 minutes.
- Seek Relief at a reading of 100 mR on your dosimeter.
- Contamination level in Alabama is twice (2x) background.
- Do not take Potassium Iodide (KI) until instructed by your county EMA.
- Control your exposure to radiation by your time, distance and shielding.

Alabama Radiation Control
Emergency Worker Equipment

Radiation Exposure Record

<table>
<thead>
<tr>
<th>Name:</th>
<th>SS# (last 4):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency:</td>
<td>DOS#:</td>
</tr>
<tr>
<td>Date: (M/D/Y)</td>
<td>TLD#:</td>
</tr>
</tbody>
</table>

Note! Read dosimeter every 30 minutes

<table>
<thead>
<tr>
<th>#</th>
<th>Time (24 hr)</th>
<th>Reading</th>
<th>Status (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial Reading</td>
<td>Low Range</td>
<td>High Range</td>
</tr>
<tr>
<td>2</td>
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<td>20</td>
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</tr>
</tbody>
</table>
Emergency Worker Training
Radiological Survey Meter(s)
Ludlum 14C
Ludlum 14C

Response
Audio
Reset
Battery Check

Scale
Probe Connector
Multiplier Switch
Battery Compartment
Radiation Contamination

Survey Meter = Speedometer

Only Use Top Scale: Counts per minute CPM or C/M
Ludlum 14C Scale(s)

0-6,600 CPM Pancake Probe

0-2.0 mR/hr HP Probe

Hairline

0-2.0 mR/hr Use on X100 only HP Probe
Ludlum 14C-Set Up & Operation

Survey Meter Calibration
Cal Date Due Date
Model Serial #
* Range within 10%

Act. Range +/- 20%
[44-2]
[44-9]
[44-36]

Calibrated By:
Alabama Radiation Control
Montgomery, AL • 334-206-3391
Ludlum 14C
What is the Meter Reading?

360 CPM
Ludlum 14C
What is the Meter Reading?

80 CPM
Ludlum 14C
What is the Meter Reading?

54,000 CPM
Ludlum 14C
What is the Meter Reading?

6,200 CPM
Ludlum 14C

What is the Meter Reading?

OFF-SCALE: Need to change “Multiplier Switch” to x1. Check cable and batteries “RESET” button.
What is the Meter Reading?

180,000 CPM
Ludlum 14C

What is the Meter Reading?

42,000 CPM
Ludlum 14C

What is the Meter Reading?

2,400 CPM
Ludlum 14C

What is the Meter Reading?

400,000 CPM
Ludlum 14C
What is the Meter Reading?

540 CPM
Ludlum 14C Monitoring for Contamination

- Probe open window
- Hold probe 1 inch away
- Start at the head
- Move probe 1 inch per second
- Remember soles of feet
- Survey thyroid gland (probe closed window)
- Contamination
  - Twice background
  - 2 x background
Ludlum 14C
Surveying the Thyroid Gland

- Probe closed window
- Place probe
  - 1 inch away
  - Adams Apple
- Multiply count rate by .04
- Thyroid uptake limit (5 rem)
## PERSONNEL/EQUIPMENT MONITORS

### Radiation Dosage Limits

**TEDE (Total Effective Dose Equivalent)**

<table>
<thead>
<tr>
<th>Monitoring evacuees/emergency workers and equipment for radiation contamination.</th>
<th>TEDE</th>
<th>Dosimeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek Relief</td>
<td>200 mrem</td>
<td>100 mR</td>
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<td>5 rem</td>
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</table>

In addition to the above individual limits, all emergency workers are advised to make a reasonable effort to limit their total dose, while at the same time accomplishing their emergency responsibilities.

Alabama Radiation Control
Thyroid Uptake Limits

- Read dosimeters and record every 15-30 minutes.
- Seek Relief at a reading of 100 mR on your dosimeter.
- Contamination level in Alabama is (2x) twice background (shield open) and will warrant decontamination.
- Monitoring technique: 1 inch away and move 1 inch per second.
- Survey thyroid with shield in closed position.
- On lowest scale (x0.1) the Ludlum 14c meter scale will read 0-600 cpm.
- Check background and instrument operation and cover probe.
- Use CPM scale when monitoring for contamination.

<table>
<thead>
<tr>
<th>Thyroid Uptake Limit</th>
<th>5 Rem</th>
</tr>
</thead>
<tbody>
<tr>
<td>INSTRUMENT</td>
<td>CDE THYROID DOSE*</td>
</tr>
<tr>
<td>Ludlum 14C (shield closed)</td>
<td>(rem/cpm above background)</td>
</tr>
<tr>
<td></td>
<td>.04*</td>
</tr>
</tbody>
</table>

Multiply count rate (cpm) by *multiplier to determine committed dose equivalent (CDE) to the thyroid in rem.

Alabama Radiation Control
Portal Monitors Setting Up

Used to screen large populations for radioactive contamination
Portal Monitors
Screening for Contamination

7/18/2017
ADPH-Office of Radiation Control
Monitoring for Contamination
Flow Chart

SURVEY ALL EVACUEES FROM CONTAMINATED AREAS

Contamination = 2 X Bkgd
Ludlum 14 Bkgd around 50 CPM

> Bkgd
& < 2 X Bkgd

Recommend Shower & Change Clothes

Resurvey

> 2 X Bkgd

Required Shower & Change Clothes

Resurvey

> 2 X Bkgd

Detailed Shower & Change of Clothes

YES

Contact Radiation Control Agency

> 2 X Bkgd

NO

Go to Registration

> 2 X Bkgd

YES

Go to Registration
Personnel Monitoring Equipment

Radiation Exposure Record

Vehicle Monitoring/Decontamination Record

Personal Monitoring/Decontamination Record

External Contamination

ThyroSafe

Electronics Display

7/18/2017

ADPH-Office of Radiation Control
Personnel & Equipment Training
Ludlum 14C & Portal Monitors
Glossary

• **ALPHA RADIATION** – A positively charged particle emitted from the nucleus of a radioactive element. It has a low penetrating power and has a short range - a few inches. Alpha particles are not an external hazard but are extremely hazardous when introduced into the body.

• **ALARA** – An acronym for As Low As Reasonably Achievable. An approach to radiation protection to control or manage exposures as low as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process to keep dose levels as far below applicable limits as reasonably achievable.

• **BACKGROUND RADIATION** – The radiation in the natural environment, including cosmic rays and radiation from the naturally radioactive elements, both outside and inside the bodies of humans and animals. It is also called natural radiation. The average individual exposure from background radiation is 620 millirem per year.

• **BETA RADIATION** – A negatively charged particle emitted from the nucleus during radioactive decay. It has a medium penetrating power and a range of up to a few feet. Large amounts of beta radiation may cause skin reddening, and are harmful if they enter the body. Beta radiation is an external and internal hazard.

• **CONTAMINATION** – The deposition of unwanted radioactive material on the surface of structures, areas, objects, or personnel. Radioactive material in a location where it is unwanted.

• **CPM** – An acronym for counts per minute and is associated with contamination surveys. The pancake probe (44-9) with the Ludlum 14C is used when detecting for contamination.

• **DECONTAMINATION** – The reduction or removal of radioactive material from a location where it is unwanted.

• **DOSIMETER** – A portable instrument or device used for measuring and registering the total accumulated exposure to ionizing radiation. Examples are pocket dosimeter, TLD or film badge.

Glossary

- **EMERGENCY WORKER** – An individual performing duties to protect the health and safety of the public during a radiological emergency (e.g., firemen, school bus driver, police, highway personnel, medical personnel, etc.)

- **EXPOSURE** – The absorption of radiation or ingestion of a radionuclide.

- **EXPOSURE RATE** – The measure of radiation by a device (survey meter) over some time period, usually an hour.

- **GAMMA RADIATION** – A high energy photon emitted from the nucleus of an atom. It has the most penetrating power and a range of up to hundreds of feet. Gamma rays will penetrate the internal organs, therefore, they are an internal and external hazard.

- **GEIGER-MUELLER COUNTER** – A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage but no current flowing. When ionizing radiation passes through a tube, a short intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of radiation.

- **ION** – An atom that has too many or too few electrons, causing it to be chemically active; an electron that is not associated (in orbit) with a nucleus.

- **IONIZING RADIATION** – Any radiation capable of displacing electrons from atoms, thereby producing ions. Examples: alpha, beta, gamma, x-rays, neutrons and ultraviolet light. High doses of ionizing radiation may produce severe skin or tissue damage.

- **INVERSE SQUARE LAW** – The law states the gamma rays intensity is inversely proportional to the square of the distance from a point source. Therefore, doubling the distance from a point source of gamma radiation decreases the exposure rate to one-fourth (1/4) the original exposure rate.
Glossary

• **IONIZATION** – The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiation can cause ionization.

• **LITHIUM FLUORIDE** – A chemical compound used in thermoluminescent dosimeters.

• **KCPM** – An acronym for kilo counts per minute (thousands of counts per minute).

• **MILLI** – A prefix meaning one-thousandth (1/1000) or divides a basic unit by 1000. For example, millirem is one-thousandth part of a rem.

• **PERSONNEL MONITORING EQUIPMENT** – Devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), and pocket dosimeters.

• **POTASSIUM IODIDE (KI)** – A chemical form of stable iodine that can be used by the body to block absorption of radioiodine by the thyroid gland.

• **RAD** – An acronym for Radiation Absorbed Dose. The special unit of absorbed dose. One (1) rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

• **RADIATION** – Is energy in the form of rays or high-speed particles. Radiation occurs naturally as in sunlight. Radiation is also manmade in the form of x-rays, medical treatments, nuclear weapons, and commercial nuclear power facilities. All forms of electromagnetic radiation make up the electromagnetic spectrum.

• **RADIOACTIVE MATERIAL** – Any material which spontaneously emits particle or photon radiation in an effort to expend excess energy.

• **RADIOACTIVITY** – The spontaneous emission of radiation, generally alpha or beta particle often accompanied by gamma rays from the nucleus of an unstable isotope.
Glossary

- **RCA** – An acronym for Radiation Control Agency.

- **REM** – Roentgen Equivalent in Man. The special unit of dose equivalent in man. It is measurement of the effect of all types of radiation on the human body.

- **ROENTGEN (R)** – A unit of exposure to ionizing radiation in air. It is radiation effect in air from x-rays or gamma rays.

- **SHIELDING** – Any material or obstruction that absorbs radiation and thus tends to protect personnel or material from the effects of ionizing radiation.

- **SURVEY METER** – Any portable radiation detection instrument adapted for inspecting an area to establish the existence and amount of radioactive material present.

- **TEDE** – An acronym for Total Effective Dose Equivalent. Total Dose = External Dose + Internal Dose.

- **THERMOLUMINISCENT DOSIMETER (TLD)** – An extremely accurate device used to measure and provide a permanent record of exposure to radiation.

- **X-RAY** – A photon originating from the electron cloud rather than from the nucleus of an atom. One form of electromagnetic radiation. It has penetrating power like gamma radiation. X-rays will penetrate the internal organs, therefore, they are an internal and external hazard.