BASIC RADIATION
and GUIDANCE TRAINING

Emergency Medical Service (EMS) Personnel

State of Alabama
Alabama Department of Public Health
Office of Radiation Control

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Although emergencies at nuclear power plants are very unlikely, we still need to prepare ourselves to respond in case there is a major release of radiation to the atmosphere.

This training provides information on radiation and how Emergency Medical Service (EMS) personnel may assess, package, and transport a patient while controlling the spread of contamination and protecting themselves from the harmful effects of radiation.
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In Alabama there are two nuclear power plants. Plant Farley resides in Houston County near Dothan, Alabama and Plant Browns Ferry resides in Limestone County near Athens, Alabama. There is a possibility that a third nuclear power plant, Bellefonte located in Jackson County may become operational in the future.

Browns Ferry has four risk counties (counties within the 10-mile radius) and one host county for the overflow of the evacuees. The risk counties are: Limestone, Morgan, Lawrence, and Lauderdale. The host county is Madison.

Farley has only two risk counties (Houston and Henry) because of their geographic location and ownership of the Chattahoochee River. We coordinate our response activities with Georgia.

We train all emergency workers and personnel & equipment monitors in the 10-mile EPZ (Emergency Planning Zone). The EPZ is the 10-mile radius around the plant.

Training and equipment are the same across the entire state of Alabama. We keep a training database to keep track of trained personnel. We appreciate assistance from trained personnel in the event of a radiological incident at one of the nuclear power plants.
There are four Emergency Classification Levels (ECL) at all U.S. nuclear power plants. Nuclear power facilities use the ECLs as the method of communicating different types of incidents affecting the plant. Each ECL describes the specific actions that must be completed by both the licensee and the offsite emergency responders. Emergency classifications are declared for events that are occurring or have occurred affecting plant radiation safety or plant security. Each time an ECL is declared or changed, the State EOC Communications Center and/or the Utility (owner of plant) are required to make notifications to the responsible state agency, the Office of Radiation Control.

**Notification of an Unusual Event** - The least serious of the four classifications. Events in this class indicate:
- Potential degradation of plant safety
- Security threat to facility protection is initiated
- No release of radioactive material unless plant conditions degrade

**Alert** - An Alert is declared when:
- Potential or actual degradation in plant safety occurs
- Lives of onsite personnel may be threatened or site equipment may be damaged due to a hostile action

**Site Area Emergency** - A Site Area Emergency is declared when:
- Actual or likely plant functions will fail. Plant functions would be needed to protect the public’s health and safety
- Hostile actions occur that result in an intentional damage to plant personnel or equipment used to protect the public
- Malicious acts that could lead to failure of equipment used to protect the public or could prevent effective access to said equipment used to protect the public
- Radiation Control issues two health orders, Restrict Access of the 2-mile radius of the plant and Public Warning health order. Radiation Control will also send out radiological field monitoring teams to survey the area. We currently have two state teams and two county teams.

**General Emergency** - A General Emergency is declared when events:
- Involve actual or imminent significant core degradation or melting. There is the potential for loss of containment integrity
- Include hostile action that results in an actual loss of physical control of the facility
- Based on the field measurements, wind speed, wind direction and status of the plant, Radiation Control could issue evacuation health orders, or other health orders that are applicable.
The Radiological Emergency Response Plan is the policy of the State of Alabama. The plan details the concept of radiological emergency planning and operation for off-site emergency response and recovery in the event of a radiological accident at a nuclear power plant.

For Browns Ferry Nuclear Power Plant, the hospitals and emergency medical services who have agreed to be part of the Alabama Radiological Emergency Response Plan for Nuclear Power Plants are: Decatur Morgan Hospital (Decatur General Campus), Decatur Morgan Hospital (Parkway Medical Campus), Huntsville Hospital, First Response EMS, and Greg’s Ambulance Service.

For Farley Nuclear Power Plant, the hospitals and emergency medical services who have agreed to be part of the Alabama Radiological Emergency Response Plan for Nuclear Power Plants are: Southeast Alabama Medical Center, Flowers Hospital, and Pilchers Ambulance.
Radiation

- **Radiation** is energy from an unstable atom 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.

Radiation is a process where energy travels from one point to another by waves or particles, like the waves on the surface of the ocean. Radiation comes in various forms. A good example is the sun. Radiation is used everyday to improve our quality of life, from medical treatments to warming leftovers.

Atoms are the basic for all matter, consisting of a nucleus (made up of neutrons and protons) and electrons. Naturally, only certain combinations of protons and neutrons occur. Some are stable and some unstable. Stable nuclei have no excess energy, but unstable nuclei become stable by releasing energy. This releasing energy is commonly called radioactivity. Radiation takes the form of either non-ionizing radiation or ionizing radiation.
The REM is the unit of dose equivalence and is the measure which accounts for the varying effects of different types of radiation on the human body. Two other units that are important in the scientific study of radiation are the ROENTGEN and RAD (radiation absorbed dose). But for our purposes, one roentgen equals one rad equals one rem.

**Roentgen** is a measurement of radiation effect in air from x-rays or gamma rays.

**REM** is an acronym for Roentgen Equivalent in Man. It is the measurement of the effect of all types of radiation on the human body.

**RAD** is an acronym for Radiation Absorbed Dose. It is a measurement of the energy deposited in matter.
An average American’s annual effective dose is about 620 millirem per year. A millirem is 1/1000th of a rem. Roughly 311 millirem come from natural sources; 300 millirem comes from man-made sources, primarily medical applications such as x-rays. Less than 1 millirem comes from nuclear power generation.

Virtually everything emits radiation. Naturally occurring radiation is contained in rocks, soil, trees, and even materials within the human body. We are constantly exposed to cosmic radiation from the sun and outer space. Medical procedures, such as x-rays and diagnostic tests, can result in 20 to several thousand millirems of radiation a year, depending on a person’s treatment for disease or injury. Radiation is also present in consumer products such as tobacco products, smoke detectors, lantern mantels, domestic water supplies, and building materials. The following table gives an overview of common examples of exposure to manmade radiation.

**Manmade Radiation Exposure**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Exposure Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest x-ray</td>
<td>10 mrem/yr</td>
</tr>
<tr>
<td>Mammogram</td>
<td>30 mrem/yr</td>
</tr>
<tr>
<td>Consumer Products</td>
<td>11 mrem/yr</td>
</tr>
<tr>
<td>Cross-country flight</td>
<td>5 mrem/yr</td>
</tr>
<tr>
<td>Cigarette Smoke</td>
<td>280 mrem/yr</td>
</tr>
</tbody>
</table>
In Alabama, we have two nuclear power plants and approximately 500 licensees that are authorized to use radioactive material. The types of licensed uses include medical, industrial and research. We also have naturally occurring radioactive material or (NORM) in the state. In addition, the Department of Energy (DOE) has shipments of low level waste as part of the Waste Isolation Pilot Plant (WIPP) that come down I-59 and I-20.

**Nuclear Power Plants:** Browns Ferry and Joseph M. Farley  
**Medical Uses:** Medical uses include hospitals, cancer centers, cardiology clinics and nuclear pharmacies.  
**Industrial Uses:** Industrial radiography companies in Alabama use radioactive material to x-ray welds at temporary job sites including paper mills, chemical plants, shipyards, oil and gas pipelines, etc. Well Logging Companies use radioactive material to help study geological formations. Moisture density gauges are commonly used by highway construction crews at job sites to help determine moisture content and compaction of the soil.  
**Research:** Most of the universities in Alabama have radioactive material licenses for research purposes.  
**NORM:** Naturally Occurring Radioactive Material. In South Alabama around Citronelle or Gilbertown, you will find elevated levels of NORM due to the scale that has accumulated on the gas wells piping and in the tanks. If it is greater than 50 microR/hr at the surface we require them to dispose of it through a radioactive waste broker. We have also seen piping from paper mills that had elevated radiation levels caused by kaolin clay used in the process. Kaolin is a white clay found primarily in Alabama and Georgia containing elevated levels of uranium and thorium decay series. In the paper process it is used to produce high gloss for magazines and beer packaging. In Muscle Shoals there is a giant slag pile with elevated radiation levels that exceed 100 microR/hr due to the byproducts created as part of the National Fertilizer Company in the 1970's. This is under exclusive federal jurisdiction as part of TVA.  
**WIPP:** The WIPP program started in 1999 and its purpose is to secure national defense related transuranic waste below ground in the remote desert of New Mexico. Shipments come through Alabama from Oak Ridge National Lab and Savannah River National Lab. We are notified of these shipments and have computer access to track these shipments via GPS while they travel through Alabama. Transuranic waste is man-made isotopes that are heavier than uranium.
There are two types of radiation: non-ionizing and ionizing.

One type of radiation, non-ionizing radiation, has enough energy to cause electrons within atoms to vibrate, but not enough to remove them from the atom itself. For example, microwave ovens use electromagnetic waves to force the molecules in food and water to vibrate; thus the faster a molecule vibrates the hotter the food becomes. However, these electrons do not break away from the atoms of the food. We also come in contact with many types of non-ionizing radiation daily, such as the sun that delivers light and heat. Other examples of non-ionizing radiation include visible light, heat, and radar waves.

Ionizing radiation comes in two forms: particulate and waves or rays. Ionizing radiation is more energetic than non-ionizing radiation. Ionizing radiation does have enough energy to remove electrons from atoms, thus forming ions. When ionizing radiation passes through material, it deposits enough energy to break molecular bonds and displace (or remove) electrons from atoms thus creating ions. Ions are two electrically charged particles which may cause changes in living cells of plants, animals, and people. These types of radiation are associated with nuclear power plant generation. In nuclear power generation, fission (splitting an atom’s nucleus) takes place which results in radiation being produced by splitting an atom’s nucleus and may be emitted in three forms: alpha particles, beta particles, and gamma rays.
Alpha radiation

- Positively charged particle that cannot penetrate the skin
- Relatively large and slow moving
- Travels only a few inches in air
- Internal hazard only

Alpha particle - A positively charged particle emitted from the nucleus of an atom.

Alpha particles are charged particles which are emitted from naturally occurring materials (such as uranium, thorium, and radium) and man-made elements (such as plutonium and americium). These alpha emitters are primarily used (in very small amounts) in items such as smoke detectors.

In general, alpha particles have a very limited ability to penetrate other materials. In other words, these particles of ionizing radiation can be blocked by a sheet of paper, skin, or even a few inches of air. As a result, alpha particles do not usually make anything radioactive. Nonetheless, materials that emit alpha particles are potentially dangerous if they are inhaled or swallowed, but external exposure generally does not pose a danger.
Beta particle- A negatively charged particle emitted from the nucleus of an atom.

In general, beta particles are lighter than alpha particles, and they generally have a greater ability to penetrate other materials. As a result, these particles can travel a few feet in the air and can penetrate skin. Nonetheless, they can be stopped by several sheets of paper, i.e. a thick book, a sheet of aluminum and of course denser materials. Beta particles are both an internal and external hazard.
Gamma ray- A photon originating from the nucleus of an atom.

Gamma rays and x-rays consist of high-energy waves that can travel great distances at the speed of light and generally have a great ability to penetrate other materials. For that reason, gamma rays (such as from cobalt-60) are often used in medical applications to treat cancer and sterilize medical instruments. Similarly, x-rays are typically used to provide static images of body parts (such as teeth and bones), and are also used in industry to find defects in welds. X-rays and gamma rays have great penetrating power and can easily pass through the human body.

Thick, dense shielding, such as lead, is necessary to protect against gamma rays. The higher the energy of the gamma ray, the thicker the lead must be. X-rays pose a similar challenge, so x-ray technicians often give patients receiving medical or dental X-rays a lead apron to cover other parts of their body.

Gamma rays are an external and internal hazardous.
The ALARA philosophy is the foundation for all exposure (dose) limits. ALARA is based on the assumption that a radiation exposure of any amount is a potential hazard. ALARA means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, thus As Low As Reasonably Achievable.

Do not spend more time than necessary near a radiation source. Stay as far away from a radiation source as you can. Place material between you and the source of radiation.

Use a common sense approach when dealing with radiation!
We cannot eliminate radiation from our environment. But we can, however, reduce our risk by controlling our exposure to it. Radiation is very easily detected. There are several simple, sensitive instruments capable of detecting minute amounts of radiation from natural and man-made sources. There are three ways in which people can protect themselves from ionizing radiation:

1. Time
2. Distance
3. Shielding
For people who are exposed to radiation, in addition to natural background radiation through their work, the dose is reduced and the risk of illness essentially eliminated by limiting exposure time.

If you decrease the amount of time you spend near the source of radiation, you will decrease the amount of radiation exposure you receive. To imagine this, think of a trip to the beach as a comparison. For instance, if you spend a lot of time on the beach, you will be exposed to the sun, and, ultimately, get a sunburn. If you spend less time in the sun and more time in the shade, your sunburn will be much less severe. This is similar to the way radiation exposure works.

The less time you spend in a radiation area, the less dose you will receive. Emergency workers will be assigned to work in a radiation area only for the amount of time required to accomplish their particular task.

For example, if you were working in an area where the exposure rate was 50mR/hr and you stayed there for one (1) hour, you would receive a dose of 50 millirem. But if you remained there for only a half an hour (30minutes), you would receive half the dose or 25 millirem.
The farther away you are from a source of ionizing radiation, the less dose you will receive. In the same way that heat from a fire is less the farther away you are, the intensity of radiation decreases as you distance yourself from the source.

Because of the Inverse Square Law (1/d²), a responder can quickly make radiation exposure estimates. The law states when you double your distance from a point source of radiation, you will reduce the exposure by a factor of 4. If you triple the distance from a point source of radiation, you will reduce the exposure by 9. See the illustration labeled Figure 1.

Example: If your measured exposure rate at a distance of two (2) feet from a point source of radiation is 20 mR/hr, then the distance is doubled to four (4) feet away; the exposure rate will now only be ¼ which is 5 mR/hr.

Example: If you are two (2) feet from a point source of radiation reading 20 mR/hr, then you triple your distance to six (6) feet away, then the exposure rate will be 1/9 which is 2.2 mR/hr.

Distance x 2 = 1/4
Distance x 3 = 1/9
Distance x 4 = 1/16
Distance x 5 = 1/25
The use of shielding, such as lead, steel, concrete, or earth, between you and a source of radiation will also reduce your exposure. The amount of reduction depends on the type and thickness of the shielding material. Barriers of lead, concrete, or water give good protection from penetrating radiation such as gamma rays. Radioactive materials are therefore often stored or handled under water, or by remote control in rooms constructed of thick concrete or lined with lead.

If you increase the shielding around a radiation source, it will decrease your exposure. For example, if you stand out in the rain without an umbrella, you will get wet. But, if you use an umbrella to shield you from the rain, you will remain dry and protected. This is similar to the idea of shielding in radiation protection.

So when possible, emergency workers in radiation areas should take advantage of shielding (standing behind buildings, cars or some other means of shelter) to reduce their exposure. Keep something substantial between you and a point source of radiation. In the event of a radioactive plume, sheltering while the plume passes may be helpful.
Radiation exposure is energy that passes through a material and may do damage but does not contaminate. So when a person is exposed to radiation, it does not necessarily mean that the person is contaminated. In order to become contaminated, a person has to be physically in contact with the radioactive material. When radioactive material is where it is not wanted (e.g., on the ground, in water, or on you), we refer to it as “contamination”. Contamination is measured in counts per minute (cpm) and disintegrations per minute (dpm).

If someone is contaminated (externally), most of the material could be easily removed from the body by removing the clothing and washing with a mild soap and shampoo.

Example: We all go to the dentist and periodically receive an x-ray of our teeth. The energy of the x-ray travels through our tissue and teeth which develops the film to be read by the dentist. The x-ray passed through our teeth but did not physically touch our body in any way. Note: X-rays, CT scans, fluoroscopy, (any machine produced radiation), does not contaminate the patient.
External contamination occurs when radioactive material is deposited on an individual’s body and/or clothing. Removing the clothing and showering with a mild soap will probably remove the external contamination. In stubborn cases, a second shower may be required.

A trained person with a survey instrument will be able to detect contamination on an individual and will be able to decontaminate them externally.
A contaminated individual may have also sustained a physical injury. In all cases, the treatment of an injury takes priority over decontamination.

Contamination is nothing more than a nuisance. Injuries come first and decontamination comes second.
External hazards of radiation dose are beta particles and gamma rays. Beta particles can cause burns to the skin. Gamma rays are very energetic and can penetrate through internal organs.

Internal hazards of radiation dose are alpha particles, beta particles, gamma rays and neutron particles. Once inside the body, they all become very harmful internal hazards. Radiological materials may enter the body by ingestion, by inhalation, or by absorption through a cut or break in the skin such as a wound.
In a radiation emergency at a nuclear power plant, radioactive iodine in the form of I-131 may be released into the air. Potassium Iodide can help prevent radioactive iodine from being absorbed into your thyroid gland only.

All radioactive material targets different parts of our bodies. Some are organ seekers, bone seekers, blood seekers, etc.. Radioactive iodine is a thyroid seeker. Our thyroid gland works like a sponge. We’re going to fill the thyroid gland up with nonradioactive iodine in the form of KI (Potassium Iodide). If radioactive iodine happens to be breathed in, the thyroid gland is already full and would not accept much more, if any. The radioactive iodine would be excreted from your body with minimal damage.

When there is a need for Potassium Iodide, KI will be made available to you. Potassium Iodide is stockpiled at the county health departments (Houston, Morgan, Lawrence, Lauderdale, and Limestone) in the possession of the county health nurse. If you are told to take KI, take either two (2) 65 mg tablets or one (1) 130 mg tablet for every 24 hours you are exposed to radioactive iodine. Do not take more often and do not take this drug if you know you are allergic to iodine.
Acute dose- A one time, limited, or short term dose. The greater the radiation dose and the shorter the period of time it is received, the greater the risk to the individual. Note: Radiation therapy is not the same as chemotherapy.

Large doses of radiation directed specifically at a tumor are used in radiation therapy to kill cancerous cells, and thereby often save lives. Much larger doses are used to kill harmful bacteria in food, and to sterilize bandages and other medical equipment. Radiation has become a valuable tool in our modern world.

Chronic dose- Continuous or long term dose. With a chronic dose, the effects are the results of radiation dose over a long period of time, due to background or occupational radiation exposure.
Break – 10 minutes
Ionizing radiation cannot be detected by our five (5) senses. **We cannot** feel, taste, smell, see, or hear radiation. We must use radiation detection instruments such as pocket dosimeters and other equipment to know if, when, and how much radiation is present.

You must learn to read the instruments properly because the instruments will let you know if radiation is present. You have to rely on them.
Emergency workers measure their radiation exposure with a Direct-Reading Dosimeter (DRD). DRDs are a pencil-shaped instrument which can be read immediately by the wearer. Radiation exposure is measured in Roentgen (R) and Milliroentgen (mR). The DRD will let you read how much dose you have received. Pocket dosimeters are similar to odometers. The accumulated exposure recorded on a dosimeter can be compared to the accumulated distance on an odometer.

The thermoluminescent dosimeter (TLD), sometimes called a TLD card, is a laminated wallet-sized card which provides a permanent record of the wearer’s dose. TLDs are extremely accurate and will give the exact amount of exposure. The TLD card serves as your legal/permanent record to radiation.

TLD cards are so precise they will give the exact amount of dose from radiation. TLDs contain two (2) lithium fluoride chips which absorb and store the energy received from exposure to radiation. Unlike the pocket dosimeters, TLD cards can not be read directly by the user. When you complete your emergency worker duties you will turn the TLD card in to appropriate officials. The TLD will be sent off to be read and you will be notified of your dose.

Remember: The thermoluminescent dosimeter serves as your legal/permanent record.
The Direct-Read Dosimeters (DRD) are designed to measure gamma radiation and x-rays. The DRD is a pencil-shaped tube with an eyepiece at the clip end and an ion-chamber equipped with a charging pin at the opposite end. Dosimeters are fairly accurate, rugged, and can be read directly by the user. Direct-Read Dosimeters give the advantage of immediately knowing the amount of gamma radiation that the wearer has been exposed to. DRDs are not expensive and are fairly easy to use. The pocket dosimeter is read by pointing it toward a source of light and viewing the scale and hairline through the lens at the clip end of the dosimeter. When reading pocket dosimeters, always keep the scale in the horizontal position to ensure an accurate reading.

While performing the tasks of an emergency worker, read your dosimeter every 15 to 30 minutes. Record the beginning and ending dosimeter readings on the Radiation Exposure Record. The difference between the beginning and the ending is your exposure.

If your DRD is dropped (consider it contaminated) and the needle is no longer visible, then use the reporting levels from your team member. The use of another team member’s DRD reading is considered Group Dosimetry.
TLDs and DRDs are to be placed on the torso below the neck and above the waist line. The preferred location is in the chest area of the responder.

Since TLDs can not be read by the responder, TLDs can be placed on street clothes or under protective clothing.

Direct-Read Dosimeters need to be placed on the outside of the clothing whether it is street clothing or protective clothing. DRDs can be read by the responder so easy access is needed in order to read both dosimeters every 15 to 30 minutes. Record results on the Radiation Exposure Record.
The CDV-750 model 6 dosimeter charger can be used to zero a variety of Direct-Reading Dosimeters. The charger requires no batteries, but develops the charge necessary by the user squeezing the black charging lever. The clamp on the top is adjustable and will accommodate varying lengths of DRDs.

General Precautions:
The charger is fragile. Do not submit it to mechanical shock.
While inserting dosimeters into the charger, do not use extreme force in pushing the clamp against the lens end of the dosimeter.
Damage to the dosimeter may occur.

Instructions on General Use:
1. Adjust the clamp to fit the length of the dosimeter.
2. Pull the clamp trigger back and insert the dosimeter with the clip toward the back. Make sure the scale of the dosimeter is horizontal.
3. Look to see if there is a hairline needle. If there is a hairline needle, then slowly squeeze the black generator lever to “charge” or zero the dosimeter. If you don’t have a hairline needle, then give the generator lever several quick pumps while looking through for the hairline needle. The hairline needle will appear on the right-hand side. Continue squeezing the generator level until the hairline needle is on zero.
4. If the hairline needle falls below zero then press the black discharge button to bring the hairline needle back to zero.
5. Once the hairline needle is on zero, pull back the clamp trigger and take the pocket dosimeter out.
6. When the pocket dosimeter is out of the charger, take another reading to ensure the reading is still zero.
7. Record the dosimeter reading on the radiation exposure record.
Although emergency workers are not expected to be exposed to significant levels of radiation, the dosimeter reading values are shown in the right hand column. The administrative limit for emergency workers in Alabama is set at one-half of the EPA-recommended limits. This table shows the dosimeter readings that will most likely keep the TEDE (Total Dose) from exceeding the EPA limit. Do not exceed the limits in the right hand column and you will not exceed your TEDE (Total Dose).

The green wallet size card is for emergency workers. The 3 radiation dose limits apply to all emergency workers.

Emergency workers are instructed to seek relief at 100 mR on their dosimeter. Do not wait until the dosimeter is on 100 mR before you request relief. Remember you are recording your dosimeters every 15-30 minutes. Call to request relief when your dosimeter approaches 100 mR; this gives your replacement ample time to travel to your destination to relieve you.

- Remember 100 mR on dosimeter (external) + 100 millirem (internal) = 200 mrem TEDE.
- Which dosimeter would you be reading? Answer: Low Range (black or silver)

Emergency workers are allowed to receive 1 rem per day TEDE; your dosimeter would be reading 500 mR.

- 500 mR on dosimeter (external) + 500 millirem (internal) = 1000 mrem = 1 rem TEDE.
- Which dosimeter would you be reading? High Range (yellow)

Emergency workers are allowed to receive 5 rem maximum per accident TEDE; your dosimeter would be reading 2.5 R.

- 2.5 R on dosimeter (external) + 2.5 rem (internal) = 5 rem TEDE.
- Which dosimeter would you be reading? High Range (yellow)

The Annual Occupational Limit (AOL) for individuals who work in the radiation area are allowed to receive 5 rem per/year TEDE.

For special situations, such as life saving activities, an emergency worker could receive up to 25 rem TEDE (total). A dosimeter reading of 12.5 R.

Remember – It is recommended that the responder carry/have the green wallet-sized card at all times. This green card lists all the limits and keynotes referred in the manual.

Voluntary Responder: If a responder is going to exceed more than 12 R (25 rem TEDE), they become classified as a “Volunteer”. The Volunteer must consult and consent with appropriate officials who will explain the radiation risk.
Radioactive materials are among the many kinds of hazardous substances Emergency Medical Service (EMS) personnel may have to deal with. It is prudent, as emergency personnel, to know your role in responding to a radiation accident should one occur in your community. Emergency Medical Service personnel should always follow procedures in order to handle radiation accidents properly.

As emergency workers, EMS personnel will perform duties such as life-saving activities and packaging and transporting contaminated patients.
When the Emergency Medical Service (EMS) personnel are notified of an accident victim who is involved with or possibly contaminated with radioactive material, a planned course of action should be followed and communication should be established immediately with the receiving hospital.

If any doubt about contamination exists, assume the victim is contaminated until proven otherwise. EMS dispatch should immediately notify receiving hospital of the possibility of a radiation contaminated patient and request information on any special entrance to the Emergency Department for the radiation contaminated patient. Also provide receiving hospital the estimated time of arrival and number of victims and medical status of each.

If during a drill, before each transmission, say “This is a Drill.”
Each ambulance service is provided with two copies of the Radiation Accident booklet and response tote. It is recommended that one book be kept with the radiation response tote and one book placed with dispatch. The booklet is intended to provide a team leader guidance when assigning duties and equipment to Emergency Medical Service personnel during an event with a nuclear power plant. The booklet also has a guide for dressing and undressing personal protective clothing and preparing an ambulance for response.
To prevent the spread of radiation contamination and to continue ambulance operations, EMS personnel should take the time to prepare their ambulance.

Four (4) things are needed to prepare an ambulance: Sheets, masking tape, radiation labeled garbage bag, and undress procedure poster.

1. Cover the bench and floors of the ambulance with sheets. Tape seams along walls and door way.
2. Use tape to secure the sheets to prevent a tripping hazard.
3. Close all doors and cabinets and stow any unnecessary articles or items inside of ambulance.
4. Cover with a clear bag any equipment which may be used such as hand held radios.
5. Additional sheets (use 3-sheet method) are needed for the preparation of wrapping/coothing the patient for transport and to be used during the initial assessment at the accident scene.
6. Tape up a radiation labeled garbage bag in the back of the ambulance or on the back door of the ambulance. The garbage bag is to be used as contamination control for rad waste (glove exchange, victim’s clothing, etc).
7. Tape-up the Undress (Doffing) procedure poster labeled, “Radiation Accident Protocol Exit of the Decontamination Team”, to the back door of the ambulance to assist in undressing when instructed by the hospital Radiation Safety Officer (RSO).
8. Place box of gloves out for easy access.
9. If additional bags are needed then affix a radiation label to the bag.
The purpose of protective clothing is to keep bare skin and personal clothing free of contaminants. EMS personnel should properly dress out in anti-C clothing and follow the instructions on the “Dress Out Instructions” poster or packet. Anti-C clothing consist of coveralls, head cover, mask w/eye and mouth protection, and gloves. Waterproof shoes covers (Yellow) are also included and can be used in water areas i.e., rain. All open seams and cuffs should be taped using masking or adhesive tape. Fold-over tabs at the end of each taped area will aid in removal. Two pairs (inner orange) of surgical gloves should be worn. The first pair of gloves (orange) should be secured by tape to the sleeve of the coveralls. The second pair of gloves should be easily removable and replaced if they become contaminated. A radiation dosimeter should be assigned to each team member and attached to the outside of the Anti-C clothing at the neck where it can be easily removed and read. A TLD badge should be worn under the Anti-C clothing. EMS personnel responding to a radiological incident should use the buddy system to read (monitor) pocket dosimeters every 15-30 minutes and record on the Radiation Exposure Record.

The team leader will assign a person to distribute all radiation equipment to EMS personnel responding to an area that has been evacuated and is potentially contaminated with radioactive material. The Radiation Equipment Distribution Log is necessary for record keeping for the specific equipment issued to an individual and for the duration of the accident/incident.

Date, Name, last 4-digits of SSN, and the representing agency. Document the serial numbers of the dosimeters and the user badge number for the TLD card. Record the reading on departure and every 15-30 minutes during a mission then again on return.

Emergency response team should follow instruction on dressing out and undressing from Anti-C clothing.
To assist with the response team preparation of anti-C clothing and equipment, place the “Dress-Out Instruction” poster on the wall and follow instructions to ensure all response team members are properly dressed out. If a response member needs help with the removal of coveralls, remember to exchange gloves when finished with the task. A chair (metal or cover chair) may be used to assist with balance while doffing the personal protective equipment.

**DRESS-OUT INSTRUCTIONS**

1. Attach a TLD card (film badge) to clothes (above waist and below neck).
2. Put on disposable booties (water repellent).
4. Put on inner pair of “Orange” latex gloves (tape to sleeve – leave a tab for easy removal of tape).
5. Put on outer pair of latex gloves (do not tape).
7. Attach two pocket dosimeters above waist and below neck.
8. Put on mask with splash visor eye shield and head cover.
9. Record your TLD card (film badge serial number) and personal pocket dosimeters on form.
10. Record dosimeter serial number and reading on the RSO’s log sheet before you enter the controlled area.

If working in water areas, i.e., raining outside, put on (Yellow) plastic waterproof shoe covers over the disposable booties.
1. Dosimeters should be checked every 15-30 minutes and recorded on the Radiation Exposure Record.
2. Place a sheet on the ground to prevent you (your knees) and your equipment from becoming possibly contaminated.
3. Assess and treat life-threatening injuries immediately. **Assessing injuries should always take priority over decontamination.**
4. Exchange out of gloves frequently (universal precautions) to prevent the spread of contamination.
5. Remove the victim’s clothing, prepare and transport the victim as soon as possible.
6. Place the victim’s clothing in the prepared radiation labeled yellow garbage bag or a bag with “Radioactive Material” label on it
7. **Do not eat, drink, smoke, rub eyes or nose, apply chap stick and make-up while conducting response operations.**
1. Scene assessment: Are there any hazards? Read dosimeters every 15-30 minutes and record on the radiation exposure record (refer to page 48).


3. Place a blanket/sheet on the ground for trauma bag or equipment. The ground cover is to prevent items from being contaminated. It also provides a place to kneel down while assessing the patient.

4. Place a face shield or towel over airways (if clear) to prevent inhalation of radioactive contaminants. This can be performed right before the removal of the patient clothes.

5. Use a large bag and remove shoes. Seal and set aside. Change Gloves.

6. Responders or equipment should Never intentionally come in direct contact (knees or hands) with the ground. If this occurred then consider self or equipment to be contaminated. Use a clear bag and affix a label with “radiation” to remove an item (shears or dosimeter) or equipment from the ground. If an item or article is not needed then leave at the scene.

7. Responders and ambulance will be surveyed by personnel using a radiation survey instrument at a hospital or designated location.

If during a drill, before each transmission say, “This is a Drill.”
1. Is the patient still stable? Is scene safe? If “Yes” then proceed with response operations.
2. Prepare and fold 3-sheets/blankets as one article.
3. If needed slide a back board below the second sheet. Follow policy and procedures.
4. Place folded sheets/blankets beside patient and **SLOWLY** unfold sheet/blanket. This prevents material from becoming an airborne hazard.
5. Slowly unfold one side of sheet/blanket and place under log rolled patient. Do the same to the opposite side until patient is on top of sheets/blankets.

If there is critical change in patient’s status: Cocoon then “Load and Go”.
Video on proper technique using the 3-sheet method for field decontamination
1. Start cutting slowly at the shoulder at same rate of speed and go down to the wrist. Roll inside out and tuck underneath exposed arms.
2. Start cutting slowly down the patient’s side and with the free hand grab the clothing and roll while lifting up and away from the patient’s skin.
3. Continue cutting slowly all the way to the ankles and roll down and away from the patient. Roll the clothes inside out and tuck underneath the patient.
4. Change gloves. One responder will log roll the patient while the other responder slowly folds the top sheet over the clothes. Be careful not to step onto the second sheet/blanket.
5. Now log roll the patient to the opposite side and fold the sheet over the other seam.
6. Start rolling the sheet from the head toward the feet and place out away from the patient. Change gloves.
7. Conduct an assessment and determine the mechanism of injury (MOI) and treat according to local policy and procedures.
8. Change gloves as needed using “Universal Precautions” to prevent contamination spread from one location to another.
9. Wrap patient entirely with second sheet/blanket and attach back board straps. Be careful not to let straps from stretcher touch the ground. Use additional sheets/blankets to cocoon feet and head if needed.
10. Change gloves and read dosimeters and record upon departure. Relay to hospital estimated time of arrival and include “patient may be contaminated with radioactive materials.”
The hospital staff will meet the ambulance outside the emergency department or designated receiving area. A patient in stable condition should be transferred to a clean stretcher. A whole body radiation survey can be conducted prior to entering the decontamination room. The EMS personnel should remain with the ambulance. Do not eat, drink, dip, apply chap stick or make-up while awaiting release by the Radiation Safety Officer.

Before leaving the area the ambulance and personnel shall be monitored for contamination. If contamination is found, a shower and change of clothing is required. A final survey by the hospital’s Radiation Safety Officer (RSO) is required before leaving the area. If the ambulance is found to be contaminated, the ambulance will be directed to the emergency worker decon station to be decontaminated (cleaned). Contact your local county EMA for the locations of the emergency workers decontamination stations.
To properly remove the anti-C clothing and equipment and to eliminate unnecessary cross contamination, when exiting the controlled area, place on the wall beside the decontamination room doorway and viewable at the step off pad the “Radiation Accident Protocol Exit of the Decontamination Team” poster and follow instructions.

RADIATION ACCIDENT PROTOCOL
FOR THE EMS RESPONSE TEAM

1. Remove outer latex gloves and put in a waste container.
2. Give pocket dosimeter to Radiation Safety Officer (RSO) or Health Physics (HP) Technician. Be sure that reading is recorded upon exit.
3. Remove mask w/splash visor eye shield and head cover and put in a waste container.
4. If (Yellow) plastic waterproof shoe covers were needed, remove them and put in a waste container.
5. Remove tape from wrists, coveralls, and plastic waterproof shoe covers and put them in a waste container.
6. Remove coveralls (slowly pull downward to ankles).
7. Step out of coveralls and put in a waste container.
8. Remove disposable booties (one at time) and put in a waste container while stepping over the control line (RSO or HP tech may monitor bottom of shoes at this time).
9. Remove inner pair of “Orange” latex gloves and put in a waste container.
10. Remove TLD (or film badge) and give to RSO or HP Tech.
11. Receive a complete whole-body survey with a Geiger Mueller survey meter from the hospital personnel.
12. If survey indicates the presence of contamination, DO NOT leave the area until assisted by the Radiation Safety Officer (RSO).
The REAC/TS staff are available 24 hours a day/seven days a week to deploy and provide emergency medical consultation for incidents involving radiation anywhere in the world. REAC/TS is recognized for its expertise in the medical management of radiation incidents.
# Radiation Exposure Record

<table>
<thead>
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<th>Name:</th>
<th>SS# (if cl):</th>
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<tr>
<td>Start Date:</td>
<td></td>
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<tr>
<td>Total Daily Exposure / Admin. Unit:</td>
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</tbody>
</table>

**Note:** Read dosimeter every 30 minutes

<table>
<thead>
<tr>
<th>#</th>
<th>Date (MDY)</th>
<th>Time (24 hr)</th>
<th>Reading</th>
<th>Status (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low (0.0 uSv)</td>
<td>High (0)</td>
</tr>
<tr>
<td>1</td>
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## Equipment Distribution Log

<table>
<thead>
<tr>
<th>#</th>
<th>Date (mm/dd)</th>
<th>Name</th>
<th>Type:</th>
<th>Instrument(s)</th>
<th>TLD Card</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>08/01/2023</td>
<td>John Doe</td>
<td>Low</td>
<td>Geiger Counter</td>
<td>TLD Card</td>
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<tr>
<td>2</td>
<td>09/15/2023</td>
<td>Jane Smith</td>
<td>High</td>
<td>Thermometer</td>
<td>TLD Card</td>
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<tr>
<td>3</td>
<td>07/22/2023</td>
<td>Bob Johnson</td>
<td>Medium</td>
<td>Dosimeter</td>
<td>TLD Card</td>
</tr>
<tr>
<td>4</td>
<td>10/03/2023</td>
<td>Lisa Lee</td>
<td>Low</td>
<td>Probe</td>
<td>TLD Card</td>
</tr>
<tr>
<td>5</td>
<td>08/31/2023</td>
<td>Kevin Davis</td>
<td>High</td>
<td>Geiger Counter</td>
<td>TLD Card</td>
</tr>
</tbody>
</table>

*Note: TLD stands for Thermoluminescent Dosimeter.*
Glossary

- **ALPHA RADIATION** – A positively charged particle emitted from the nucleus of an 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 of an atom. It has a medium penetrating power and a range of up to a few feet. Beta particles will penetrate the skin, therefore, they are 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 14+ is used when detecting for contamination.

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

- **DOSI METER** – A portable instrument or device used for measuring and registering the total accumulated exposure to ionizing radiation. Examples are pocket dosimeters, TLD or film badge.

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

• **EXPOSURE** – The quantity used to indicate the amount of ionization in air produced by x-rays or gamma radiation.

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

• **GAMMA RADIATION** – A photon origination 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.

• **IONIZING RADIATION** – Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, when passing through matter.

• **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). It is denoted by “m”. (e.g., milliroentgen, millirem, etc.)
- **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. It is a measurement of the energy deposited in matter.
- **RADIATION** – The energy propagated through space or through a material medium such as waves. (e.g., energy in the form of electromagnetic waves or of elastic waves.)
- ** RADIOACTIVE MATERIAL** – Material which spontaneously emits particle or photon radiation in an effort to expend excess energy.
Glossary

- **RADIOACTIVITY** – The spontaneous emission of radiation, generally alpha or beta particle often accompanied by gamma rays.

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

- **REM** – An acronym for Roentgen Equivalent in Man. It is measurement of the effect of all types of radiation on the human body.

- **ROENTGEN (R)** – A measurement of radiation effect in air from x-rays or gamma rays.

- **TEDE** – An acronym for Total Effective Dose Equivalent. Total Dose = External Dose + Internal Dose. The TEDE comes from doubling (2x) the dosimeter reading.

- **THERMOLUMINESCENT 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 that 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.