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Radiation Response Briefing Manual:

A Guide for Key Leaders and Public Health Decision Makers

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

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Introduction

During a radiation emergency, state and local authorities will need to assess the degree of the hazard quickly and issue the appropriate protective actions to people in the affected area. This briefing manual is intended to serve as a just-in-time training for key decision makers. The goal of this briefing manual is to quickly enhance your awareness of the following topics:

- Radiation hazards
- Types of radiation emergencies
- Roles and responsibilities of various response agencies
- Decisions that need to be made to protect the public
- Response phases
- State and Federal radiation response assets
- Important planning and guidance documents

Scope

This guide provides a just-in-time overview of radiation hazards and response considerations for radiation emergencies. It is intended to give you a working knowledge of radiation emergency response, so that you can ask the right questions, work effectively with partner agencies, and make informed decisions. This guide is not a substitute for coordinating emergency planning and response activities with radiation professionals.

Target Audience

The intended audience for this document includes public health officials, emergency managers, and elected officials involved in planning for and managing the public health response to a radiation emergency.

What do I need to know about radiation?

Types of Radiation

The radiation we are concerned about is ionizing radiation. Ionizing radiation is energy that is given off from radioactive materials. This radiation is strong enough to damage cells in the body. At high doses, enough cells could be damaged to cause serious illness, or even death.

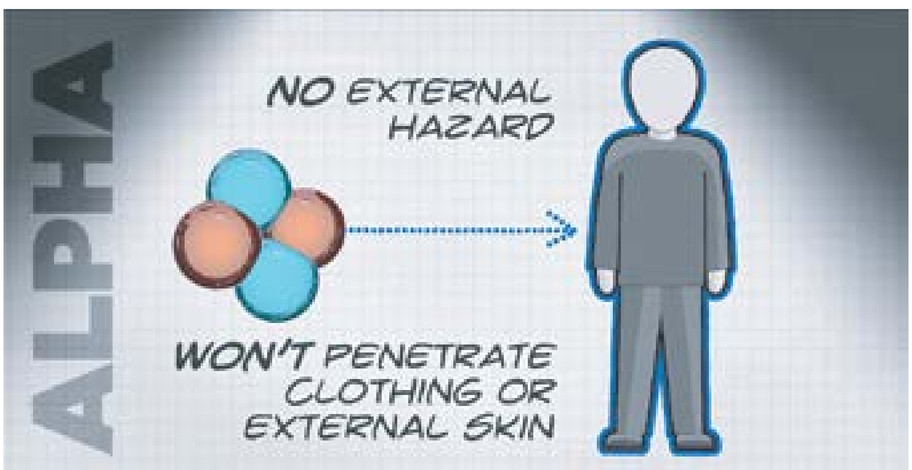
Radiation from other sources, such as radios, cell phones, and microwaves, is called non-ionizing radiation. Non-ionizing radiation does not pose the same hazard that ionizing radiation does.

There are three types of ionizing radiation you need to be aware of:

- Alpha particles
- Beta particles
- Gamma rays

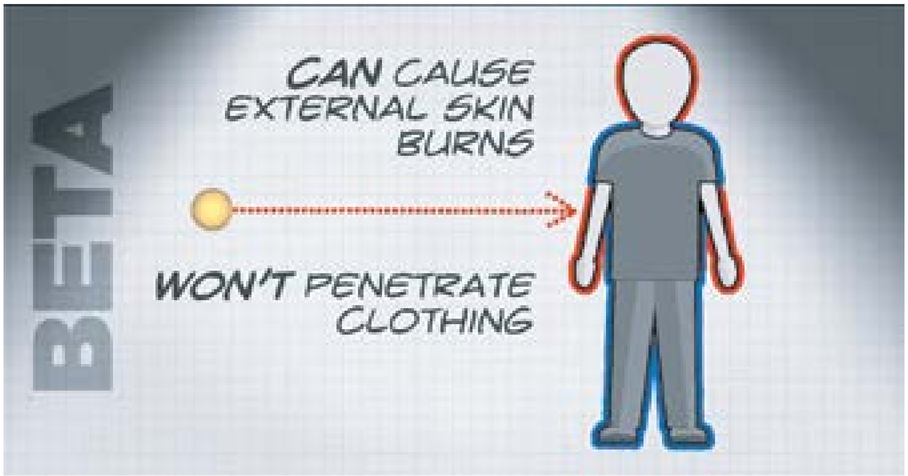
Different radioactive materials give off different types of radiation. We refer to different types of radioactive material as "radionuclides." The following are examples of different radionuclides:

- Polonium-210 is a radionuclide that gives off radiation in the form of alpha particles.
  - We refer to it as an "alpha emitter."
  - Alpha particles can't penetrate the skin, so alpha emitters are only a hazard if you internalize them by ingesting them, inhaling them, or getting them in a wound.



Alpha particles – no external hazard; won't penetrate clothing or skin

- Strontium-90 is a radionuclide that gives off radiation in the form of beta particles.
  - We refer to it as a "beta emitter."
  - Beta particles can damage the skin and can also damage cells from inside the body.
  - Beta emitters are a hazard if they get on your skin or inside your body.



Beta particles - can cause skin burns; won't penetrate clothing or plastic

- Cesium-137, as it decays, is a radionuclide that leads to the emission of radiation in the form of gamma rays.
  - We refer to it as a "gamma emitter."
  - Gamma rays can travel directly through the body, damaging cells in the skin and other organs along the way.
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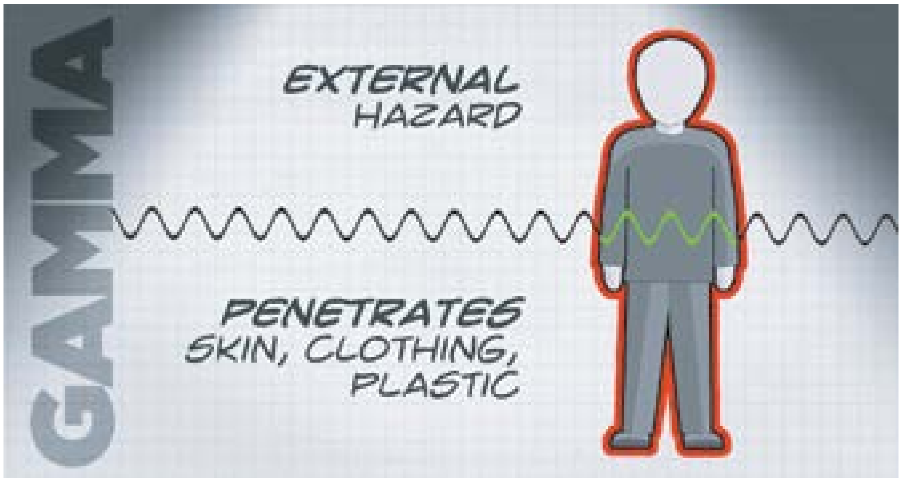
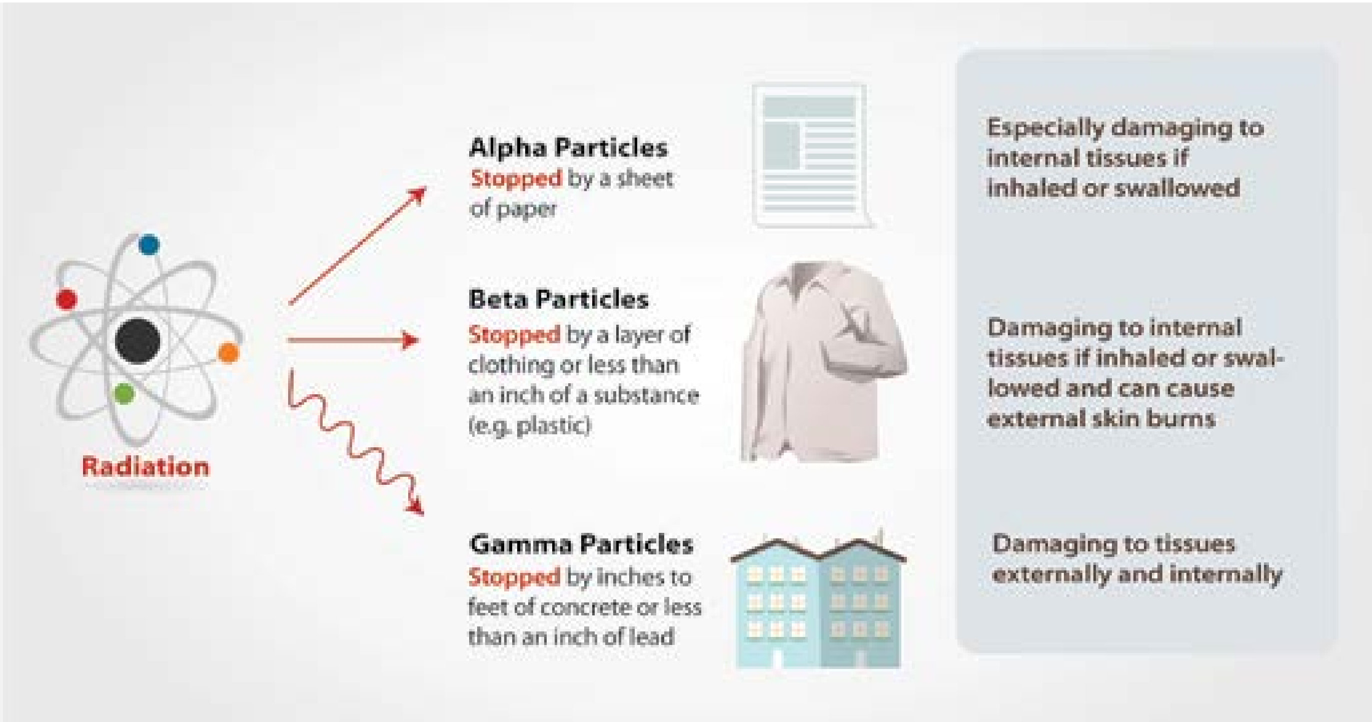


Gamma rays – external hazard; penetrates skin, clothing, plastic



Atom showing penetration abilities of alpha and beta particles and gamma rays. Alpha particles stopped by sheet of paper; beta particles stopped by layer of clothing; gamma rays stopped by inches to feet of concrete like a building

Radiation Measurement

The two units of measurement for radiation are the International System (SI), commonly used in most of the world, and conventional units, commonly used in the United States. Table 1 lists radiation units and their conversion factors. Appendix A provides more information on units of radiation measurement.

Table 1: Units of Radiation Measurement

Measurement	SI Unit	Conventional Unit	Conversion
Activity (How much radiation is present in the environment?)	Becquerel (Bq)	Curie (Ci)	37 billion Bq = 1 Ci
Absorbed Dose (How much radiation is interacting with my body?)	Gray (Gy)	rad	1 Gy = 100 rad
Equivalent Dose or Effective Dose (How much damage will it do?)	Sievert (Sv)	rem	1 Sv = 100 rem

Radioactive Contamination

Radioactive contamination is simply radioactive material that is somewhere it is not supposed to be.

There are two types of radioactive contamination that can affect people:

- External Contamination – Radioactive material that gets on your skin, hair, or clothing.
- Internal Contamination – Radioactive material that gets inside your body.

A person with radioactive contamination on the outside of their body

A person with radioactive contamination on the inside of their body

In most cases, removing contaminated clothing and washing exposed skin with mild soap and warm water will remove external contamination.

Internal contamination is harder to remove. We have some medicines – also known as medical countermeasures – that help to remove radioactive material from the body. These countermeasures only work for specific radionuclides and are most effective when taken at the appropriate time. Appendix B provides more information on the medical management of radiation casualties and the use of medical countermeasures.

If you are contaminated, you have radiation on you or inside you. Depending on how contaminated you are, you may pose a threat to people around you. The best course of action is to carefully remove contaminated clothing and wash exposed skin with mild soap and warm water.

Radiation Exposure

Radiation exposure is a measure of the amount of ionizing radiation that interacts with your body. Think of a lamp sitting on a table. When you turn on the lamp, the lightbulb emits light throughout the room. You are exposed to that light. When you turn off the lamp or leave the room, you are no longer exposed to the light. Similarly, if you step behind a corner or place a barrier between you and the lamp, you are no longer exposed to the light.

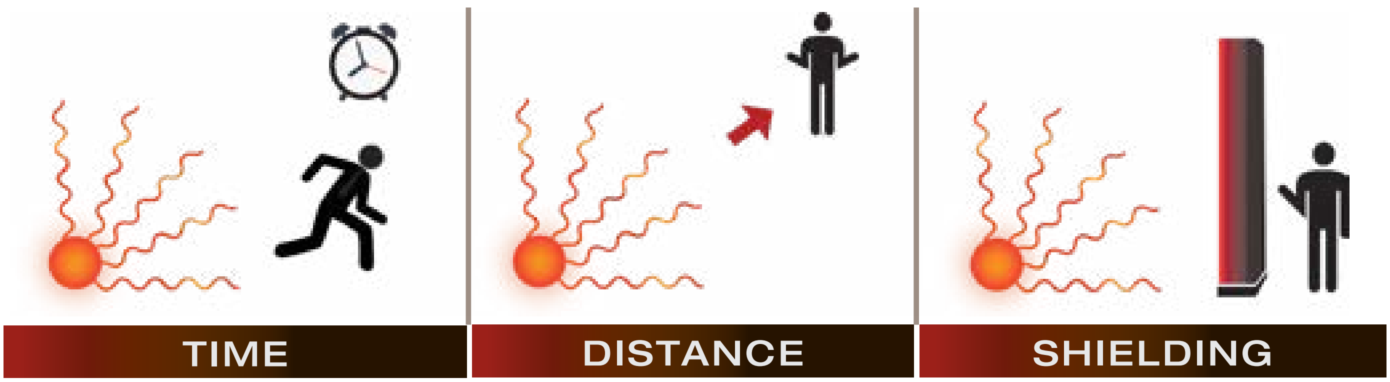
If we had a Cesium-137 source instead of a lamp, you would be exposed to gamma rays instead of rays of light. The amount of radiation you receive from a radiation source is called your radiation dose. The size of your radiation dose depends on:

- The strength of the source
- Your proximity to the source
- The amount of time you spend near the source

The best way to limit your radiation dose is to:

- Minimize your *time* near the source
- Maximize the *distance* between you and the source
- Place *shielding* (e.g., a wall, or another barrier) between you and the source

Once you leave the area, you are no longer being exposed to radiation from that source, and you do not take any radiation with you. You are not radioactive, and you do not pose a threat to others around you.



Images depicting time, distance and shielding from a radiation source

Radioactive Decay

As radioactive atoms give off radiation, they lose energy and become more stable. This process is called radioactive decay. Each radionuclide decays at a specific rate, known as the half-life. The half-life is the amount of time it takes for half of the atoms in that radioactive material to reach a stable state.

Depending on the radionuclide, this process could be fast or take a very long time – radioactive half-lives can range from milliseconds to hours, days, and even millions of years. A good rule of thumb is that, after seven half-lives, you will have less than one percent of the original amount of radiation.

Radionuclides used in nuclear medicine procedures have short half-lives. For example, Technetium-99m, one of the most common medical isotopes used for imaging studies, has a half-life of 6 hours. The short half-life of Technetium-99m helps keep the dose to the patient low. After 24 hours, the radioactivity from the procedure will be reduced by more than 90%.

On the other hand, uranium is a radionuclide that has an extremely long half-life. Naturally occurring Uranium-238 present in the Earth's crust has a half-life of almost 4.5 billion years. If you take a soil sample anywhere in the world, including your backyard, you will find uranium atoms that date back to when the Earth was formed.

If you are responding to a radiation emergency, knowing the half-life of the radionuclides involved will be important. This information will help you determine what the short- and long-term risks will be to people in the affected area.

What are the different types of radiation emergencies?

There are two broad categories of radiation emergencies:

- Radiological incidents
- Nuclear incidents

Radiological incidents involve the release or dispersal of radioactive material, but they do not involve a nuclear detonation. Types of radiological incidents are listed below.

Radiological Incidents

Radiological Dispersal Device (RDD)

An RDD is a device that uses explosive or non-explosive means to spread radioactive contamination. A dirty bomb is an example of an explosive RDD. An example of a non-explosive RDD is a crop duster used to spread radioactive liquid. RDD's present a contamination and an exposure hazard.

Radiological Exposure Device (RED)

An RED is a device that is placed in a location with the intent of exposing people to dangerous levels of gamma radiation. An RED could be placed under a seat in a bus or subway car, or it could be placed near a popular gathering spot, such as a coffee shop or a park. An RED could be made from a radioactive material, such as Cobalt-60, or it could be made from an electronic source of radiation, such as an X-ray machine. RED's present an exposure hazard. When people leave the area, they are no longer exposed.

Nuclear Power Plant Accident

Accidents at or attacks against a nuclear power plant are radiological incidents, not nuclear incidents. This distinction is made because the accident or attack results in only the spread of radioactive material, not a nuclear detonation.

Radioactive material released from a nuclear power plant can contaminate a large area, but the resulting radiation levels are usually not high enough to be life threatening. However, health officials may advise people to relocate from certain areas to prevent long-term health effects.

Transportation Accidents

When people think of transportation accidents involving radioactive material, they often think of nuclear fuel and nuclear waste being transported to and from power plants. While it is important to plan for this type of accident, these shipments are secured in reinforced containers that can withstand tremendous impact. Therefore, a transportation accident involving nuclear material that would result in a significant release is unlikely.

A more likely scenario involves the transport of radiopharmaceuticals. Radiopharmaceuticals are radioactive drugs and devices that are used for diagnosing and treating certain illnesses. These devices are transported to and from medical facilities by couriers using delivery vans, trucks, or cars. A car accident involving a radiopharmaceutical courier could result in a small release of radioactive material.

Illustrations include: Image of a dirty bomb exploding, radioactive exposure from radiation source under chair, radioactive material released from a nuclear power plant, and transportation of radioactive materials by trucks or vans.

Industrial Accidents

Examples of industries that use radioactive materials include:

- Food sterilization operations use a radiation source to kill bacteria in food that could make people sick or cause the food to spoil faster.
- Medical sterilization operations use radiation to kill bacteria on medical instruments and supplies.
- Soil density gauges used in construction and road building have a radioactive source in them that helps determine the composition of soil.
- Industrial radiography devices have a strong, but small, radioactive source that can be used to "X-ray" materials to inspect for cracks or other damage that can't be seen with the naked eye.

Industrial facility

If these sources are lost, stolen, or damaged, they could present a hazard to people in the area.

Nuclear Incidents

Nuclear incidents are much more severe because they involve nuclear fission. Nuclear fission occurs when an atom splits and the parts collide with other atoms nearby. Those atoms also split and continue a chain reaction that releases tremendous amounts of energy in the form of light, heat, and ionizing radiation.

Improvised nuclear device (IND)

An improvised nuclear device is a simple nuclear weapon that has less explosive power than a more sophisticated nuclear weapon. An IND would produce much more damage and contamination than an RDD. This is the type of nuclear weapon a terrorist organization would use.

Nuclear detonation

State-sponsored nuclear weapon

These types of nuclear weapons are very sophisticated, both in their design and delivery method. These weapons are produced by nations for military purposes. State-sponsored nuclear weapons are thousands of times more destructive than an IND.

What decisions need to be made early in a radiation emergency?

In order to make the right decisions early in the response, you need to get answers to the following questions:

- What type of incident are we dealing with?
  - If radiological:
    - What type of incident (RDD, RED, power plant, transportation, industrial)?
    - What radionuclides are involved?
    - What is the half-life for each radionuclide?
    - Is the radioactive material a solid, liquid, or gas?
    - Do we have medical countermeasures for the radionuclides involved?
  - If nuclear:
    - What type of device (IND, state-sponsored)?
    - How big was the device?
    - Where is the fallout going?
    - How quickly will the radiation levels decrease (radioactive decay)?
  - What areas are affected?
    - How much contamination is in these areas?
    - What are the radiation levels in these areas?
    - What critical infrastructure and services are impacted?
  - How many people are there?
    - How many live or work in the area?
    - How many visit or travel through the area each day?
    - Are any special events being held that would attract more people?
  - What are the primary radiation hazards (exposure, contamination)?
    - What are the other hazards (e.g., fires, collapsed buildings, secondary devices)?
    - What response assets do we need to address these hazards (search and rescues, fire, hazmat, medical)?
  - What safety precautions do responders need to take?
    - What are the safety considerations for first responders, such as police, fire, and EMS?
    - What are the safety considerations for first receivers and hospital personnel?
    - What are the safety considerations for other emergency workers and volunteers, such as staff at community reception centers and public shelters?

KEY QUESTIONS:

- ✦ Type of incident?
- ✦ Affected areas?
- ✦ How many people affected?
- ✦ Primary hazards?
- ✦ Safety precautions needed?
- ✦ Communication?
- ✦ Notifications?

- How do we communicate to people in the affected area and in the surrounding area?
  - What communications channels are available?
  - Do we have technical experts who can help craft the messages?
- What state and federal agencies do we need to notify?
  - Which agencies can provide technical assistance?

Some of these questions may be difficult to answer initially. For the radiation-specific questions, the state and federal radiation response assets identified later in this guide will be a valuable source of information.

Once you have gathered the information you need, your next step is to determine the best initial protective actions for people in the affected area. Correctly deciding whether people should evacuate or shelter-in-place will likely save the most lives during the response.

INITIAL PROTECTIVE ACTIONS

- Shelter-in-place
- Evacuation

Some radiation emergencies, such as nuclear power plant accidents, evolve slowly. For these types of incidents, it may be possible to evacuate people from an area before contamination gets there. However, evacuating large populations presents different hazards that may put people at greater risk than the potential radiation exposure. For example, congested roadways can lead to traffic accidents and can cause delays transporting critically ill or injured patients. Furthermore, people with chronic illnesses may suffer complications due to the stress of the evacuation. It's imperative to consider the potential risks from evacuation before issuing that order.

For radiation emergencies that develop more quickly, the best course of action is for people to shelter-in-place until radiation experts can assess the hazard and provide further instructions. An incident involving an RDD is unlikely to distribute enough contamination to present a serious exposure hazard to people in the area. However, people who leave a safe structure will put themselves at risk for internal and external contamination. Even though determining which areas are contaminated will take time, the best course of action in this case is to encourage people to shelter-in-place until authorities know where contamination is present.

Sheltering in place is even more important for an IND. Radioactive fallout from an IND presents a serious exposure hazard. Staying inside a sturdy building will protect people from the radiation outside. People who try to evacuate too soon will be putting themselves in danger by being outside in a highly radioactive environment. Radioactive fallout loses energy quickly and becomes less dangerous as time passes. After 24 to 48 hours, radiation levels will decrease to a fraction of what they were initially, making evacuating the area much safer for people.

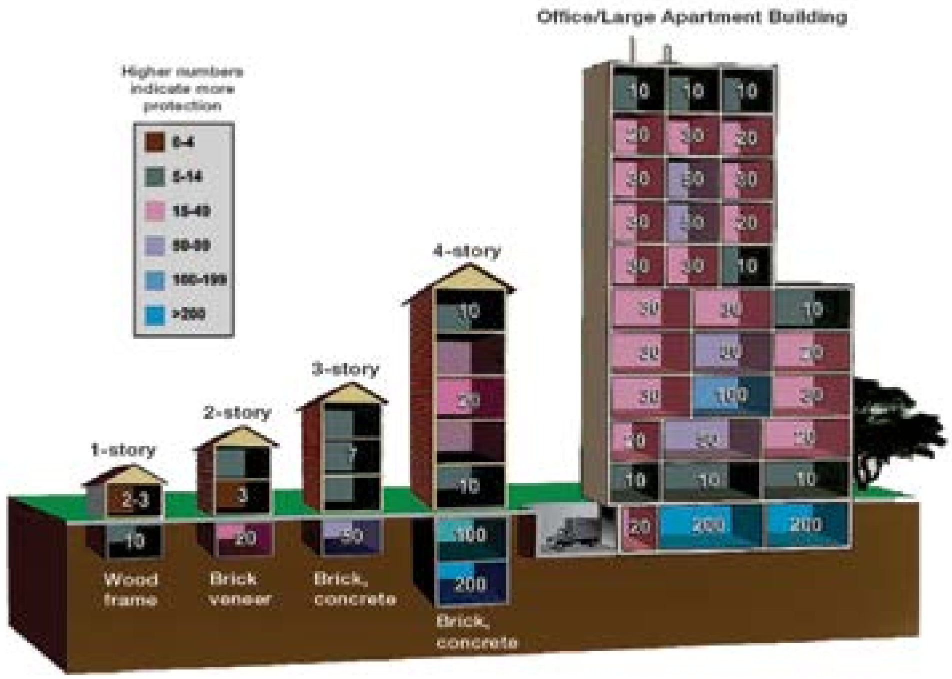
In a Radiation Emergency:

Get Inside

Stay Inside

Stay Tuned

Icons showing going inside; staying inside; staying tuned



Building as Shielding. For an accessible version of this illustration, please go to: https://www.remm.nlm.gov/buildingblast.htm

What are the roles and responsibilities of various agencies?

The response by federal agencies to a major radiological emergency is outlined in the 2016 Nuclear/Radiological Incident Annex (NRIA) to the Response and Recovery Federal Interagency Operational Plans1. The NRIA defines the roles and responsibilities of different federal agencies and discusses the specific authorities, capabilities, and assets that the federal government can bring to bear. It also discusses how these assets will organize and operate in conjunction with each other and with local and state response partners.

Depending on the nature of the radiological incident, certain federal agencies may be designated as the "primary authority" – meaning that this agency is responsible for coordinating the activities of other federal agencies and working directly with state and local agencies. The NRIA contains detailed information about which agencies have primary response authority for different radiological or nuclear incidents. Table 2 provides a synopsis of this information.

[1]The NRIA is available at https://www.fema.gov/media-library/assets/documents/25554

Table 2: Primary Authority for Radiation Emergencies

Primary Authority for Federal Response	Type of Incident
Department of Homeland Security (DHS)	Incidents involving RDDs, REDs, INDs, or deliberate attacks on radiological or nuclear facilities
Nuclear Regulatory Commission (NRC)	Incidents at NRC licensed facilities, including nuclear power plants Transportation of radioactive materials licensed by NRC or Agreement States
Department of Energy (DOE)	Incidents involving radioactive materials managed by DOE, including: • Nuclear facilities • Nuclear weapons and components • Transportation of radioactive materials by or for DOE • Unwanted radioactive materials • Lost or orphaned radioactive materials
Department of Defense (DOD)	Incidents involving radioactive materials managed by DOD, including: • Nuclear facilities • Nuclear weapons and components • Transportation of radioactive materials by or for DOD • Radioactive materials in DOD space vehicles
Environmental Protection Agency (EPA)	Incidents involving radioactive materials not managed by other agencies, including: • Nuclear facilities • Transportation • International incidents that could impact the United States
U.S. Coast Guard (USCG)	Incidents not managed by other agencies that impact the coastal zone
U.S. Customs and Border Protection (CBP)	Incidents involving inadvertently imported radioactive materials
National Aeronautics and Space Administration (NASA)	Incidents involving radioactive materials in NASA space vehicles
Department of State (DOS)	Foreign incidents involving radioactive materials requiring support from the US Government

Left Photo: People arriving at a Community Reception Center   Right Photo: Person being screened for contamination using radiation detector

What responsibilities fall to public health during a radiation emergency?

Public health authorities have primary responsibility for the following actions:

- Conducting population monitoring
- Initiating health surveillance and epidemiological investigations
- Coordinating the distribution of medical resources
- Providing guidance regarding the use of altered standards of care and managing scarce medical resources

Of the responsibilities listed, conducting population monitoring is likely to be the most challenging. Population monitoring is a process that begins soon after a radiation incident is reported and continues until all potentially affected people have been monitored and evaluated for the following:

- The need for medical treatment
- The presence of radioactive contamination on the body or clothing (external contamination)
- The intake of radioactive materials into the body (internal contamination)
- The removal of external or internal contamination (decontamination)
- The radiation dose received and the resulting health risk from the exposure
- Long-term health effects

These assessments, with the exception of evaluating people for long-term health effects, should be accomplished as soon as possible following an incident. Health officials will need to establish a population registry and conduct an epidemiologic investigation to evaluate people for long-term health effects. This process may span multiple decades.

While local health agencies may initiate population monitoring, state and federal health assets will likely be needed to augment local resources. The Centers for Disease Control and Prevention (CDC) guide *Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners*[2] provides detailed information on the public health planning considerations for radiation emergencies.

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[2]*Population Monitoring: A Guide for State and Local Public Health Planners* is available at https://www.cdc.gov/nceh/radiation/emergencies/pdf/population-monitoring-guide.pdf

What is the response timeline?

Phases of Radiation Emergency Response

Radiation emergency response activities fall into three phases – early, intermediate, and late. Early phase activities are those required for lifesaving and immediate protection from radiation and radioactive materials. These activities are often based on limited information or projections. Intermediate phase activities typically involve protecting individuals from chronic exposure to radioactive materials on the ground, in bodies of water, and incorporated in or deposited on food products. Late phase activities are those designed to return the affected area to normalcy. See Table 3 for a summary of activities and planning considerations for each phase.

PHASES OF RADIATION EMERGENCY RESPONSE

- Early
- Intermediate
- Late

Delineations between phases are not strict, and their durations can vary greatly, depending on the type and severity of incident. Activities in multiple phases may occur simultaneously. For simple incidents, a complete response may take only a few hours. For large, complicated incidents, intermediate and late phase response activities may require decades. For example, recovery activities are still ongoing near the Chernobyl reactor site in Ukraine, over 30 years after the reactor accident. Appendix C contains an expanded discussion of early, intermediate, and late phase activities.

Table 3: Response and Recovery Phases for Radiation Emergencies[3]

Phase	Timeframe	Information Available	Priority Activities	Dose Limits
Early	Days to weeks	• Models and predictions • Initial environmental measurements	• Issue order to shelter-in-place (SIP) or evacuate • Conduct contamination monitoring of people and pets • Identify and treat radiation casualties • Establish exposure registry of affected populations	Issue evacuation or SIP order if: • Projected dose exceeds 10-50 mSv (1-5 rem) over 4 days
Intermediate	Weeks to months	• Ground and aerial measurements of environmental radiation • Refined models • Laboratory analysis of water, soil, vegetation, and crops	• Relocate affected populations • Impose or adjust agricultural controls • Establish re-entry into affected areas • Facilitate the eventual return of members of the public to affected areas • Establish exposure registry of affected populations	Relocate population if projected dose exceeds: • 20 mSv (2 rem) in the first year • 5 mSv (0.5 rem) in any subsequent year
Late	Months to years	• Detailed analysis of environmental radiation levels and radioactive contamination	• Determine priorities for and feasibility of cleaning important sites and infrastructure • Determine permissible alternate use of affected areas • Establish exposure registry of affected populations	• Prioritize remediation activities to achieve ALARA (As Low As Reasonably Achievable)

[3]This table is adapted from information in the *EPA PAG Manual,* available at https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

What assets are available to respond to a radiation emergency?

Many state and federal radiation response assets are available to support local authorities. When requested by local officials, these assets will fold into the operations and planning sections in the incident command structure.

State Assets

State Radiation Control[4]

Each state has a radiation control authority that regulates the use of radioactive materials. This asset is usually positioned within the state public health agency or the state environmental protection agency. The state radiation control authority will be a vital asset during the response and should be notified immediately if responders suspect an incident involves radioactive material.

National Guard Weapons of Mass Destruction Civil Support Teams (WMD CST)[5]

Each state and territory has a National Guard Weapons of Mass Destruction Civil Support Team (WMD CST). These teams are equipped to respond to suspected WMD or hazmat incidents in support of state and local authorities. In a radiation emergency, the WMD CST can help determine the extent of the hazard. The WMD CST will be the "tip of the spear" for the Department of Defense (DOD) domestic response assets and can help state and local authorities determine whether additional DOD resources are needed to assist in the response.

Radiological Emergency Preparedness (REP) Program[6]

States that have nuclear power plants have a Radiological Emergency Preparedness (REP) Program that provides training, conducts exercises, and supports emergency response activities. State and local emergency management agencies typically manage these programs. The primary mission is to coordinate preparedness efforts in the areas surrounding nuclear power plants, although REP resources and expertise could be put to use in other types of radiation emergencies.

Logos

Top: Conference or Radiation Control Program Directors

Middle: National Guard Weapons of Mass Destruction Civil Support Teams

Bottom: Radiological Emergency Preparedness Program

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[4]To locate your state radiation control office, visit http:/www.crcpd.org

[5]For more information on WMD CSTs, visit https://www.nationalguard.mil/Portals/31/Resources/Fact%20Sheets/Weapons%20of%20Mass%20Destruction%20Civil%20Support%20Team%20Fact%20Sheet%20(Dec.%202017).pdf

[6]For more information on REP, visit https://www.fema.gov/radiological-emergency-preparedness-program

Federal Assets

Department of Energy (DOE)

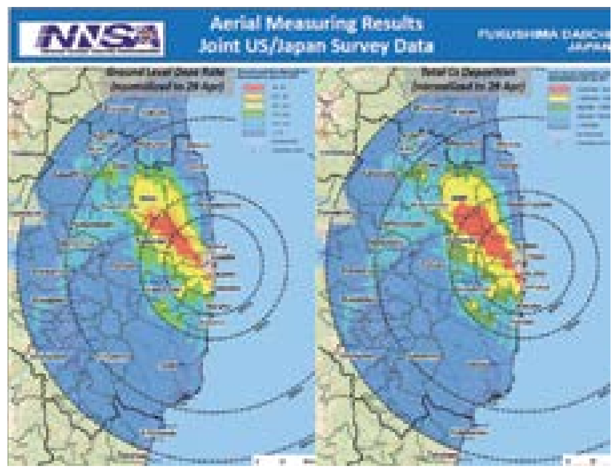
The U.S. Department of Energy (DOE) manages most of the resources used to supplement state and local efforts in a radiation emergency. These resources include:

National Atmospheric Release Advisory Center (NARAC)[7]

The National Atmospheric Release Advisory Center (NARAC) provides predictive plots and maps showing the areas affected by the radiation emergency and to what extent they are affected. Early in a response, NARAC analysts create preliminary maps based on many assumptions. As responders gather more data from the affected area, NARAC refines the maps, providing a better characterization of radiation levels in the environment.

Radiological Assistance Program (RAP)[8]

Each National Laboratory maintains on-call radiation protection personnel to respond to radiation incidents at the request of state officials. Radiological Assistance Program (RAP) teams typically deploy with hand-held radiation detection equipment. In addition to monitoring environmental radiation levels, RAP teams can collect soil, water, and vegetation samples for laboratory analysis.



Left Photo: Airplane used in the Aerial Measuring System   Right Photo: Plots from aerial radiation surveys over Fukushima, Japan

Aerial Measuring System (AMS)[9]

DOE maintains several rotary- and fixed-wing aircraft outfitted with radiation detection equipment. DOE also has the ability to equip several additional rotary-wing aircraft with the just-in-time deployment of radiation detection equipment.

AMS assets fly over the affected area in a serpentine pattern, measuring gamma radiation levels and relaying these measurements to analysts on the ground. Radiation detectors aboard fixed-wing aircraft can be rapidly deployed to an accident scene and can provide a quick look to identify suspected areas of high contamination. Rotary-wing aircraft are slower to respond, but can provide a detailed assessment of radioactive materials deposited on the ground.

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[7]For more information on NARAC, visit https://narac.llnl.gov/

[8]For more information on RAP, visit https://www.energy.gov/nnsa/leadership-and-offices/emergency-operations

[9]For more information on AMS, visit https://www.energy.gov/nnsa/aerial-measuring-system-ams

Federal Radiological Monitoring and Assessment Center (FRMAC)[10]

The FRMAC is a multi-agency organization responsible for coordinating radiological monitoring, sampling, and assessment activities. DOE staffs the FRMAC with an incident command staff from its Nevada Operations Office and personnel from the DOE National Laboratories. State and local personnel work side-by-side with federal counterparts to conduct radiation monitoring.

Logo of Federal Radiological Monitoring and Assessment Center

DOE directs the FRMAC through the immediate response phase. After environmental releases have ceased and environmental contamination has been characterized, the U.S. Environmental Protection Agency (EPA) takes control of the FRMAC to direct cleanup efforts.

Once a decision has been made to establish the FRMAC, personnel and assets move in phases. Initially, senior FRMAC staff will travel to a location near the scene to meet with state decision makers and radiation protection personnel. Over the next 72 hours, additional FRMAC personnel and assets will arrive at the FRMAC location. As FRMAC collects data from field sampling teams, NARAC analysts use this information to update contamination maps and plume models. The updated maps help create a common operating picture for federal, state, and local officials.

Radiation Emergency Assistance Center/Training Site (REAC/TS)[11]

REAC/TS is a medical asset located in Oak Ridge, Tennessee. The clinicians and health physicists at REAC/TS provide medical advice, training, and on-site assistance for the treatment of radiation injuries. During a radiation emergency response, REAC/TS personnel typically co-locate with the FRMAC and are available to provide guidance to health officials managing the medical response.

A patient being decontaminated in medical setting

[10] For more information on FRMAC, visit https://www.energy.gov/nnsa/nuclear-incident-response

[11] For more information on REAC/TS, visit https://orise.orau.gov/reacts/

Environmental Protection Agency (EPA)

The Environmental Protection Agency (EPA) maintains several assets that can assist state and local authorities during a radiation emergency. These include:

Logo of Environmental Protection Agency

RadNet[12]

EPA's RadNet is a network of 140 radiation monitoring stations that provides real-time radiation monitoring in all 50 states. The stations monitor air, precipitation, and drinking water samples. During a radiation emergency, scientists can use this information to determine the extent of the contamination and determine what protective actions to take.

Airborne Spectral Photometric Environmental Collection Technology (ASPECT)[13]

EPA's ASPECT is a fixed-wing aircraft that provides real-time chemical and radiological monitoring. During a radiation emergency, ASPECT will work with the DOE Aerial Measuring System assets to monitor radiation levels in the affected area. ASPECT can deploy within nine hours of notification.

Radiological Emergency Response Teams (RERT)[14]

EPA's Radiological Emergency Response Team (RERT) works with federal, state and local agencies to monitor radioactivity and clean up affected areas. During a radiation emergency, EPA uses its protective action guidelines to help determine what actions are necessary to protect people from unhealthy levels of radiation.

Picture of the Nationwide Environmental Radiation Monitoring System

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[12] For more information on RadNet, visit https://www.epa.gov/radnet

[13] For more information on ASPECT, visit: https://www.epa.gov/emergency-response/aspect

[14] For more information on RERT, visit https://www.epa.gov/radiation/radiological-emergency-response

Advisory Team for Environment, Food, and Health (Advisory Team)[15]

Although FRMAC, in conjunction with AMS, RAP, and NARAC, can provide a detailed characterization of the radiological consequences of an emergency, it does not provide recommendations regarding protective actions for protecting the public.

The Advisory Team consists of representatives from the EPA, the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the CDC, plus other federal agencies as needed. The Advisory Team interprets information provided by FRMAC, NARAC and other sources, and provides recommendations to the Coordinating Agency and local/state decision-makers regarding matters of health (including animal health), the environment, and food. This advice includes:

Logo: The Advisory Team for Environment, Food, and Health

- Interpretation of the EPA protective action guides (PAGs)[16]
- Actions to minimize the contamination of food and water
- Actions to minimize the ingestion of contaminated food and water
- Relocation of members of the general public
- Return of the general public to areas which had been previously evacuated

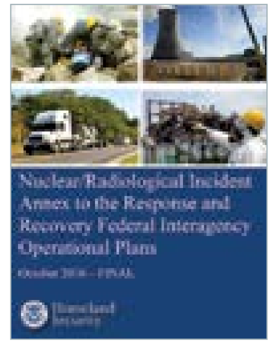
Advisory Team members may be embedded with the FRMAC or at the state or local emergency operations center. Team members may also operate remotely, participating by computer, telephone, or video-conference.

The Advisory Team members during an exercise

[15] For more information on the Advisory team, visit https://cdn.ymaws.com/www.crcpd.org/resource/resmgr/ATeam/Ateam.htm

[16] *PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents* is available at https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

What planning and guidance documents should I know about?



1. The 2016 Nuclear/Radiological Incident Annex (NRIA) to the Response and Recovery Federal Interagency Operational Plans :
   - Describes how federal agencies are organized and the processes that they will use in responding to nuclear/radiological incidents
   - Provides information that is specific and unique to federal nuclear/radiological incident response (with particular emphasis on assets, resources and teams)
   - Details how federal agencies will share information regarding suspected terrorist incidents

   The NRIA also provides information about how federal agencies will implement interagency operations plans.

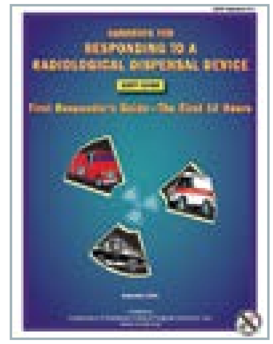
2. The CDC developed Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners to help state, tribal, and local officials determine whether their plans adequately address population monitoring. This guide also helps planners identify staffing needs, training requirements, and resources necessary to conduct population monitoring.

3. The EPA developed the PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents to help federal, state, and local responders plan for radiological emergencies. The manual contains radiation dose guidelines for triggering public protective actions, such as evacuation, sheltering-in-place, and the administration of radioprotective drugs.

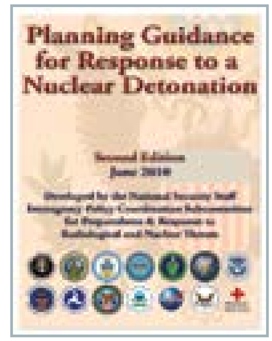
4. The CDC developed A Guide to Operating Public Shelters in a Radiation Emergency to assist planning and response efforts related to shelter operations in a radiation emergency. The document includes information and guidance concerning radiation monitoring, screening for radioactive contamination, decontamination, registration, health surveillance, and risk communication.

Column shows cover pages from the following documents: Nuclear/Radiological Incident Annex (NRIA) to the Response and Recovery Federal Interagency Operational Plans; Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners; PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents; and A Guide to Operating Public Shelters in a Radiation Emergency

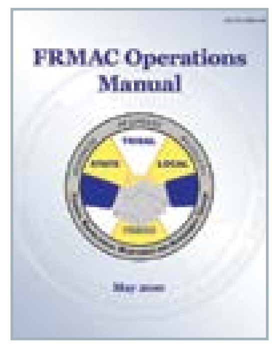
5. The Conference of Radiation Control Program Directors, Inc. (CRCPD) developed the Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours as a training tool for first responders. The handbook includes a response flow chart, rules of thumb for radiation emergencies, guidance on establishing radiation zones, and information regarding the use of radiation instrumentation. The handbook, which is available free to download or for sale in hard copy or on DVD, is accompanied by the RDD Pocket Guide.



6. National Security Staff in the Executive Office of the President prepared Planning Guidance for Response to a Nuclear Detonation to provide response personnel with guidance and recommendations for responding to a nuclear detonation. The guidance addresses the scale of destruction involved in a nuclear detonation and provides information on sheltering-in-place, evacuation, and casualty management. The guidance is applicable for the first several days in an area with severely compromised infrastructure.



7. The DOE published the FRMAC Operations Manual to describe FRMAC's activities in coordinating the federal response to a large-scale radiological incident. The manual describes FRMAC's monitoring, sampling, and assessment activities, and describes the federal assets providing those capabilities. The manual also outlines how FRMAC is incorporated into the National Incident Management System (NIMS) under the NRF. Other FRMAC manuals describe in detail FRMAC procedures for sample collection, laboratory sample analysis and assessment and worker health and safety.



Column shows cover pages from the following documents: Handbook for Responding to a Radiological Dispersal Device: First Responders Guide – The First 12 Hours; Planning Guidance for Response to a Nuclear Detonation; and FRMAC Operations Manual

Appendix A: Radiation Measurement and Risk

When scientists measure radiation, they use different terms to discuss:

- Activity – The amount or radiation coming from a radioactive source
- Absorbed Dose – The radiation dose absorbed by a person
- Equivalent Dose and Effective Dose – The biological risk that a person will suffer health effects from exposure to radiation.

This section explains some of the terminology used to discuss radiation measurement.

Units of Measurement

Most scientists in the international community measure radiation using the System Internationale (SI), a uniform system of weights and measures that evolved from the metric system. In the United States, however, the conventional system of measurement is still widely used. Table 4 lists the SI and conventional units for radiation measurement.

Table 4: Units of Radiation Measurement

Measurement	SI Unit	Conventional Unit	Conversion
Activity (How much radiation is present in the environment?)	Becquerel (Bq)	Curie (Ci)	37 billion Bq = 1 Ci
Absorbed Dose (How much radiation is interacting with my body?)	Gray (Gy)	rad	1 Gy = 100 rad
Equivalent Dose or **Effective Dose** (How much damage will it do?)	Sievert (Sv)	rem	1 Sv = 100 rem

Left Photo: Personal radiation monitor   Right Photo: Worker conducting radiation screening of someone's hands

Measuring Emitted Radiation

When the amount of radiation being emitted or given off is discussed, the unit of measure used is the conventional unit **Ci** or the SI unit Bq.

A radioactive atom gives off or emits radioactivity because the nucleus has too many particles, too much energy, or too much mass to be stable. The nucleus breaks down, or disintegrates, in an attempt to reach a nonradioactive (stable) state. As the nucleus disintegrates, energy is released in the form of radiation.

The Ci or Bq is used to express the number of disintegrations of radioactive atoms in a radioactive material over a period of time. For example, one Ci is equal to 37 billion (37×10^9) disintegrations per second.

Ci or Bq may be used to refer to the amount of radioactive materials released into the environment. For example, during the Chernobyl power plant accident, an estimated total of 81 million Ci of radioactive cesium (a type of radioactive material) was released.

Measuring Radiation Dose

When a person is exposed to radiation, energy is deposited in the tissues of the body. The amount of energy deposited per unit of weight of human tissue is called the absorbed dose. Absorbed dose is measured using the conventional unit **rad** or the SI unit **Gy**. The rad, which stands for radiation absorbed dose, was the conventional unit of measurement, but it has been replaced by the Gy.

Determining Biological Risk

A person's biological risk (that is, the risk that a person will suffer health effects from an exposure to radiation) is measured using the conventional unit **rem** or the SI unit **Sv**.

To determine a person's biological risk, scientists have assigned a number to each type of ionizing radiation (e.g., alpha, beta, gamma) depending on that type's ability to transfer energy to the cells of the body. This number is known as the Radiation Weighting Factor (w_r). Thus, **rem = rad x w_r**; **Sv = Gy x w_r**.

There are two types of measurements that quantify biological risk:

Equivalent Dose – Considers the biological impact of different types of radiation (e.g., alpha, beta, gamma) by multiplying absorbed dose by the Radiation Weighting Factor.

Effective Dose – Considers the sensitivity of specific tissues and organs to certain types of radiation, as well as the behavior of different radionuclides inside the body, by taking a sum of the equivalent doses calculated for the tissues and organs affected.

Abbreviations for Radiation Measurements

When the amounts of radiation being measured are less than 1, prefixes are attached to the unit of measure as a type of shorthand. This is called scientific notation and is used in many scientific fields, not just for measuring radiation. Table 5 shows the prefixes for radiation measurement and their associated numeric notations.

Table 5: Prefixes for Small Numbers

Prefix	Scientific Notation	Decimal	Abbreviation	Example
atto-	$1 \text{ X } 10^{-18}$	0.000000000000000001	a	aCi
femto-	$1 \text{ X } 10^{-15}$	0.000000000000001	f	fCi
pico-	$1 \text{ X } 10^{-12}$	0.000000000001	p	pCi
nano-	$1 \text{ X } 10^{-9}$	0.000000001	n	nCi
micro-	$1 \text{ X } 10^{-6}$	0.000001	µ	µCi
milli-	$1 \text{ X } 10^{-3}$	0.001	m	mCi
centi-	$1 \text{ x } 10^{-2}$	0.01	c	cGy

When the amount to be measured is 1000 (that is, $1 \text{ X } 10^3$) or higher, prefixes are attached to the unit of measure to shorten very large numbers (also scientific notation). Table 6 shows the prefixes used in radiation measurement and their associated numeric notations.

Table 6: Prefixes for Large Numbers

Prefix	Scientific Notation	Decimal	Abbreviation	Example
kilo-	$1 \text{ X } 10^{3}$	1000	k	kCi
mega-	$1 \text{ X } 10^{6}$	1,000,000	M	MCi
giga-	$1 \text{ X } 10^{9}$	100,000,000	G	GBq
tera-	$1 \text{ X } 10^{12}$	100,000,000,000	T	TBq
peta-	$1 \text{ X } 10^{15}$	100,000,000,000,000	P	PBq
exa-	$1 \text{ x } 10^{18}$	100,000,000,000,000,000	E	EBq

Clinicians and health officials can work with radiation professionals to determine the biological risk associated with a person's radiation dose.

Common Radiation Exposures

People are exposed to radiation daily from different sources, such as naturally occurring radioactive materials in the soil and cosmic rays from outer space. Table 7 shows some common ways that people are exposed to radiation and the associated doses. These values help put radiation doses in perspective.

Table 7: Examples of Common Radiation Exposures

Source of exposure	Dose in millirem (mrem)	Dose in millisievert (mSv)
One dental x-ray	0.5 mrem	0.005 mSv
Exposure to cosmic rays during a roundtrip airplane flight from New York to Los Angeles	3 mrem	0.03 mSv
One chest x-ray	10 mrem	0.1 mSv
One mammogram	70 mrem	0.7 mSv
One year of exposure to natural radiation (from soil, cosmic rays)	300 mrem	3 mSv
One CT scan	1000 mrem	10 mSv

Determining Cancer Risk

Researchers have spent decades tracking the health outcomes of populations who have been exposed to different levels of radiation, including atomic bomb survivors in Japan, nuclear medicine patients, and radiation workers. Studying these populations helps us better understand the relationship between radiation exposure and cancer risk.

The general consensus in the scientific community is that any radiation dose, even a small dose, proportionally increases a person's risk of developing cancer. That is, higher doses present a greater cancer risk, and lower doses present a smaller cancer risk. However, determining whether a particular cancer was caused by a low dose of radiation or by another factor - such as smoking, environmental contaminants, or genetic predisposition – is very difficult.

The most extensive study to date on cancer risk from radiation exposure was conducted by the National Academy of Sciences. This study, Biological Effects of Ionizing Radiation VII (BEIR VII), is the continuation of a comprehensive epidemiological investigation that looks at the long-term health effects of low-level radiation exposure.[17]

The BEIR VII study derives cancer risk projections from a range of radiation exposures and provides a comparison to baseline cancer risk for the U.S. population. People in the United States have a 42% chance of developing cancer at some point in their lives. To put it another way, for every 100 people in the United States, 42 will develop cancer. According to the BEIR VII study, a one-time dose of 100 mSv (10 rem) results in a 1% increase in cancer risk, or an additional one case of cancer per 100 people.

In the report, the BEIR VII authors note that estimating cancer risk for doses below 100 mSv (10 rem) is more difficult. For example, they estimate that a dose of 10 mSv (1 rem) will result in a 0.1% increase in cancer risk, or an additional 1 case of cancer per 1000 people. However, they recognize that additional research needs to be conducted to better quantify the cancer risk associated with low doses of radiation.

[17] *Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2* is available at https://www.nap.edu/catalog/11340/health-risks-from-exposure-to-low-levels-of-ionizing-radiation

Appendix B: Medical Management of Radiation Casualties

Radioprotective Drugs

Some incidents may lend themselves to the use of radioprotective drugs. These drugs work in one of the following ways:

- Blocking internal contamination from being absorbed in particular organs
- Binding internal contamination to speed up excretion from the body
- Stimulating the bone marrow to produce white blood cells

The drugs that work to block or bind internal contamination are:

- Potassium Iodide (KI)
- Prussian Blue
- Diethylenetriaminepentaacetic acid (DTPA)

The drugs that work to stimulate the production of white blood cells are granulocyte colony stimulating factors (G-CSF), such as filgrastim. After a large radiation dose, the number of white blood cells drops, leaving people susceptible to infection. By stimulating the production of new white blood cells, filgrastim helps prevent infections that could be fatal after a radiation exposure.

Clinicians and radiation professionals will need to work together to identify the specific radioactive material and the radiation levels involved in an incident before administering radioprotective drugs. Depending on the nature of the incident, the distribution of medical countermeasures may be widespread (e.g., KI) or very selective (e.g., DTPA). The efficacy of these drugs depends largely on the timeliness of administration, as outlined in Table 8.

Acute Radiation Syndrome

Acute Radiation Syndrome (ARS), or radiation sickness is a serious illness that can develop when a person receives a high dose of radiation, usually over a short period of time. People exposed to radiation will get ARS only if:

- The radiation dose was high
- The radiation was able to reach internal organs (penetrating)
- The person's entire body, or most of it, received the dose
- The radiation was received in a short time, usually within minutes

Symptoms of ARS include nausea, vomiting, headache, and diarrhea. These symptoms start within minutes to days after the exposure, can last for minutes up to several days, and may come and go.
After the initial symptoms, a person usually looks and feels healthy for a period of time, after which he becomes sick again. The symptoms and severity vary depending on the radiation dose. Symptoms include loss of appetite, fatigue, fever, nausea, vomiting, diarrhea, and possibly even seizures and coma. This stage of illness may last from a few hours up to several months.

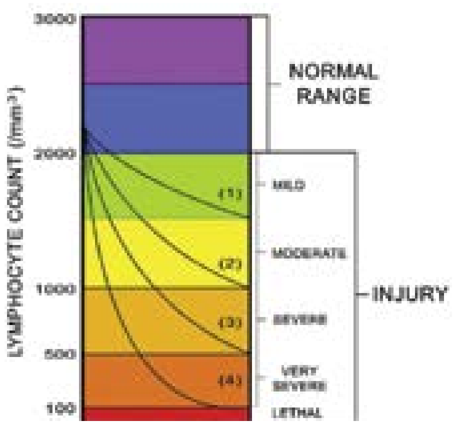


Illustration: Graph showing the degree of radiation injury based on lymphocyte count

Treatment of ARS focuses on reducing and treating infections, maintaining hydration, and treating injuries and burns. Some patients may benefit from treatments that help the bone marrow recover its function. The lower the radiation dose, the more likely it is that the person will recover from ARS. The cause of death in most cases is the destruction of the person's bone marrow, which results in infections and internal bleeding. For survivors of ARS, the recovery process may last from several weeks up to 2 years.

Table 8: Medical Countermeasures for Internal Contamination and Radiation Injury

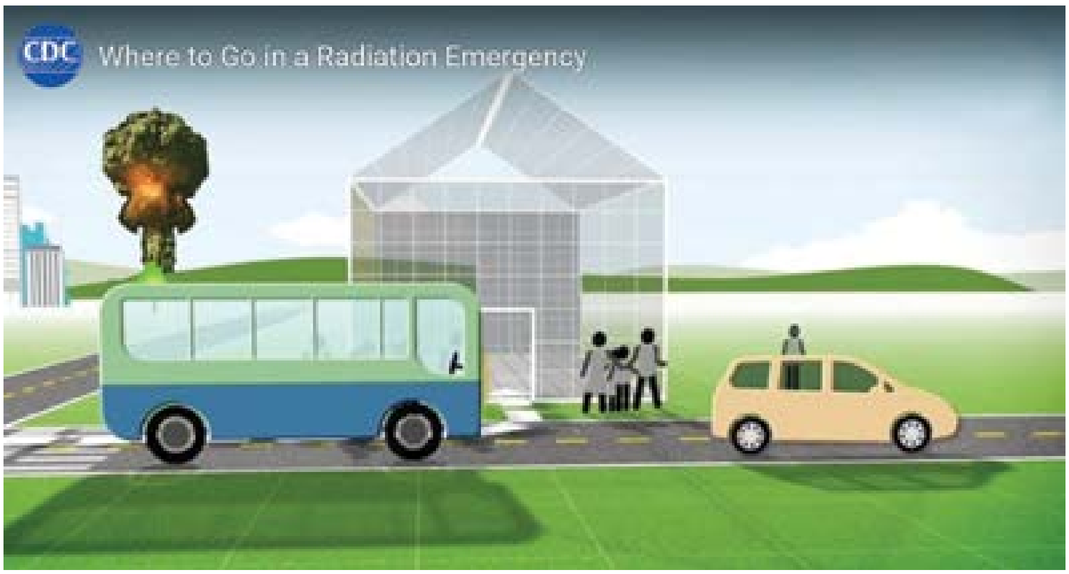
Countermeasure	Radionuclide	What it Does	Timeframe	Setting for Administration
Potassium Iodide (KI)	Radioactive iodine	Saturates thyroid gland with stable iodine, blocking the uptake of radioactive iodine.	Before exposure (most protective) or within 4 hours after exposure.	Notified by emergency officials, self-administered.
Prussian Blue	Cesium and thallium	Binds cesium and thallium and keeps them from being absorbed into the body. Contamination is excreted in the feces.	As soon as possible after internal contamination. Most effective in the first few days.	Prescribed by physician, self-administered.
DTPA	Plutonium, americium, and curium	Binds plutonium, americium, and curium and keeps them from being absorbed into the body. Contamination is excreted in the urine.	As soon as possible after internal contamination. Most effective within 24 hours.	Prescribed and administered by physician.
Filgrastim	Used to treat high radiation exposure. Not radionuclide-specific.	Stimulates bone marrow to produce new white blood cells. Helps patients fight off infections during recovery.	As soon as possible after lab testing confirms drop in white blood cell count.	Prescribed and administered by physician.

Appendix C: Phases of Radiation Response

Early Phase Actions

The primary early phase activity is lifesaving. Lifesaving activities are not anticipated for commercial reactor accidents, but may be required for most other accident types. Typically, lifesaving efforts involve treating physical injury or trauma and not radiation injury.

For transportation accidents and RDD detonations, lifesaving efforts are expected to be of short duration and involve a limited number of victims. Nuclear detonations, however, may result in a large number of victims. Intense search and rescue efforts may be required to locate and recover injured people, and treatment may be complicated by damage to local medical facilities and crowding at those facilities still in operation. Lifesaving activities related to a nuclear detonation may still be in progress weeks after the incident.



Cartoon of “where to go in a radiation emergency” showing a nuclear explosion in the back and people getting off a bus and off a car and getting inside a building structure

Sheltering-in-Place

Sheltering-in-place involves directing people to get indoors and stay indoors during an incident. Sheltering is considered a short-term protective measure, lasting a few hours to no more than two to three days, depending on the nature of the incident. Radiation professionals may recommend sheltering either when a radiation incident is expected to be of a short duration (e.g., a single “puff” release of radioactive material from a facility) or in those incidents, such as a nuclear detonation, where sheltering for a period of time allows radioactive fallout to decay (lose energy), making evacuation safer.

Evacuation – showing many cars on a highway

Evacuation

Evacuation involves directing people to leave an area affected by a radiation emergency. Ideally, radiation professionals would recommend evacuation prior to any release of radioactive material, but in most cases, doing so is not possible. The exception is commercial nuclear power plant accidents, where radiation professionals may project the effects of radioactive materials releases based on the status of plant systems, wind speed, weather conditions, and other factors. Officials then compare these projections to the EPA Protective Action Guides (PAGs)[18]. If the projected doses exceed the PAGs, officials will recommend evacuation[19]. Preparedness planning in jurisdictions near nuclear reactors includes the designation of evacuation routes and reception centers for the evacuated population.

For other radiation emergencies, evacuation will be recommended on an ad hoc basis. Incident Command, perhaps in conjunction with radiation professionals, will need to determine areas to be evacuated and where to direct evacuees, often with little or no information other than general wind direction.

Evacuation of a large population will likely result in many people needing shelter, possibly for an extended period of time. Local officials will determine the need for shelters and will often open them in conjunction with non-governmental agencies such as the American Red Cross. Planning in jurisdictions near commercial nuclear power plants requires the pre-identification of shelter locations. Most local agencies have identified shelters for other disasters. Typical locations include schools, churches, and public recreation facilities. These locations can also be used to shelter people displaced by a radiation emergency. CDC's Guide for Operating Public Shelters in a Radiation Emergency[20] can assist with planning and response efforts related to shelter operations in a radiation emergency.

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[18]*PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents* is available at https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf

[19] They may recommend shelter-in-place if there are impediments to evacuation such as weather, road conditions, etc

[20]*A Guide to Operating Public Shelters in a Radiation Emergency* is available at https://www.cdc.gov/nceh/radiation/emergencies/pdf/operating-public-shelters.pdf

Helicopter flying over crops

Contamination Monitoring

Whether people in the affected area shelter-in-place or evacuate, they will need to be monitored for radioactive contamination to ensure they are free of contamination. Contamination monitoring can be conducted at community reception centers (CRCs), shelters, or at other locations where it would facilitate response efforts.

For small events, such as transportation accidents and even small RDDs, contamination monitoring may be performed locally by first responders. For larger incidents, contamination monitoring may require separate facilities and significant personnel and equipment resources. CDC has published several documents that address establishing CRCs for radiation monitoring.[21] CRCs are locations people can go to be:

- Screened for radioactive contamination
- Decontaminated (if necessary)
- Registered for long-term follow-up
- Referred for additional medical care

These services are core components of population monitoring. In many jurisdictions, public health agencies are responsible for planning for population monitoring; however, these agencies often lack the resources and personnel to implement these plans. Successful implementation of population monitoring plans at the local level will require close coordination with response partners, such as radiation control, hazardous materials teams, volunteer organizations, and medical facilities.

For large events, such as a nuclear detonation, sheltering and population monitoring activities may take place a great distance from the incident site – possibly hundreds of miles away. Agencies initially uninvolved with incident response may nevertheless become involved with population monitoring activities.

[21]*Population Monitoring: A Guide for State and Local Public Health Planners* is available at https://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf

Identify and Treat Radiation Casualties

Radiation casualties include people who are exposed to high levels of radiation, internally contaminated with radioactive materials, or both. While radiation injuries present with a well-known clinical progression, these injuries can complicate or impede the care of other types of injuries, such as lacerations and deep wounds, thermal and chemical burns, and compound fractures. Prompt diagnosis and early intervention generally improve outcomes. Treatment of radiation casualties typically involves a combination of decorporation therapy (i.e., removing radionuclides from the body), administration of drugs to boost the immune system, antibiotic therapies to prevent infection, and administration of drugs to manage symptoms of acute radiation syndrome, such as nausea and vomiting. An overview of the medical management of radiation casualties can be found in Appendix B. Public health and medical planners need to be familiar with the following resources for radiation response planning:

- The Radiation Emergency Assistance Center and Training Site (REAC/TS) employs clinicians and health physicists to provide medical advice, training, and on-site assistance for the medical management of radiation injuries.[22]
- The Radiation Injury Treatment Network (RITN)[23] is a consortium of medical centers that provides care for radiation injuries, including bone marrow transplants.

These resources should be notified early in a radiation response to provide assistance with triaging and treating radiation casualties.

Establish an Exposure Registry

An exposure registry established early in the response will aid in the short- and long-term follow up with the affected population. People leaving the affected area can be enrolled in the registry at CRCs or other collection, evacuation, or treatment sites. Data collection for registries may be electronic or paper-based, but the information collected should be standardized across collection sites. At a minimum, the person's name, contact information, location at the time of the incident, and time spent in the affected area should be noted. If available, the person's contamination screening results should be noted in the registry, as well as any pertinent exposure information or symptoms noted by medical personnel.

The Agency for Toxic Substance and Disease Registry (ATSDR) provides a Rapid Response Registry that can be adapted for use in a radiation emergency.[24] Similarly, the CDC has developed the CRC Electronic Data Collection Tool (CRC eTool) to collect information from people reporting to CRC's.[25] Additional registry examples can be found in the Resources section of the Virtual Community Reception Center training tool.[26] Each of these tools can be modified to fit the needs of the jurisdiction using them.

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[24]For more information about the ATSDR Rapid Response Registry, visit https://www.atsdr.cdc.gov/rapidresponse/index.html

[25]The CRC eTool is available at https://emergency.cdc.gov/radiation/crcetool.asp

[26]The vCRC example registration form is available at https://orau.gov/rsb/vcrc/application/Resources/Forms/CRCRegistrationForm.doc

Intermediate Phase Actions

Intermediate phase actions are designed to protect individuals from chronic exposure to radiation or radioactive materials. These actions include:

- Imposing (and relaxing) agricultural controls
- Relocating affected populations
- Establishing re-entry into affected areas
- Facilitating the eventual return of members of the public to affected areas

The beginning of the intermediate phase, particularly for nuclear power accidents, may be considered the point in time at which releases of radioactive material have been terminated.

Small incidents, for all intents and purposes, have no intermediate phase. For example, barring a significant release of radioactive material, transportation accidents are not anticipated to require any intermediate phase responses. Other incidents may require only some of these responses. Large-scale radiation incidents, such as releases of radioactive materials from nuclear power plants, widespread contamination from an RDD, or a nuclear detonation, may require the imposition of these intermediate phase protective measures for long periods of time – years, even decades. In these incidents, the intermediate phase may be considered as the point where lifesaving activities are complete and other early phase protective measures are well in progress.

Photo: Person holding a radiation detector conducting radiation survey of a field

Left Photo: Person dressed in personal protective equipment collecting a grass sample Right Photo: Two people dressed in personal protective equipment packaging a soil sample

Agricultural Controls

Local, state and federal agricultural officials are important partners in effective radiation emergency response. These officials are responsible for setting agricultural restrictions, such as embargoes, and determining what to do with contaminated agricultural products.

Agricultural restrictions may be imposed early, even as early-phase response actions are underway. These restrictions will be based on projections of the extent and magnitude of radioactive contamination. Often, agricultural officials will advise farmers to place livestock on stored feed and protected water supplies, such as well water, to prevent them from ingesting radioactive materials. State agricultural officials often will impose embargoes on the sale or transport of agricultural products based on these same projections.

Laboratory testing of food products will be required to ultimately determine the safety of water, milk, crops, meat, eggs, and other agricultural products. Measurements of the concentrations of radioactive materials in food products will be compared to Derived Intervention Levels (DILs) established by the Food and Drug Administration (FDA)[27].

Once laboratory testing confirms that specific agricultural products in a particular area consistently exhibit radioactive material concentrations less than the DIL, agricultural officials may relax controls on those items.

Currently, no established limits or guidelines are in place for concentrations of radioactive materials in agricultural products that are not consumed as food or drink. For example, pine trees used in the manufacture of paper, soy beans used in the manufacture of plastics, and cotton used for clothing will need to be evaluated separately to determine if radioactive contamination on the raw materials will present a hazard to consumers of the manufactured product. These examples are special cases in which the Advisory Team will be key in determining appropriate concentration limits.

[27]A table outlining the FDA DILS is available at https://www.fda.gov/downloads/NewsEvents/PublicHealthFocus/UCM251056.pdf

Man and woman pushing boxes on hand truck into a truck

Relocation

Relocation is similar to evacuation, in that people leave areas where radioactive contamination may cause significant radiation exposures. The major differences are that evacuation may be recommended based solely on projections of radiation dose, and depending on the severity of a particular incident, may be only for a short period of time. Relocation, on the other hand, is a long-term protective action based on radiation measurements, sampling, and laboratory analysis. If radiation levels in an area would result in a dose of 20 mSv (2 rem) during the first year after the incident, or more than 5 mSv (500 mrem) in any year thereafter, radiation professionals will recommend for people in that area to relocate. This relocation would be at least one year in duration, and may, in extreme cases, be effectively permanent. For example, an area covering 2600 km around the Chernobyl reactor is still restricted from public access, 30 years after the reactor accident.

Re-entry

Early in the response, small numbers of people may need to re-enter the area to perform critical tasks. For example, critical infrastructure, such as communications hardware, power generation facilities, and public utilities, may be located in the affected area. Local officials will need to determine under what circumstances to allow individuals to enter the area and what measures those individuals will need to take to protect themselves from radioactive materials in the area. Often these measures will include a single point of ingress and egress and the use of dosimetry instruments and protective clothing. In heavily contaminated areas, entry may require respiratory protection and possibly an escort by radiation safety personnel.

Limited re-entry may also be allowed for personal reasons. For example, after the Fukushima Daiichi reactor accidents, the Japanese government permitted limited re-entry under tightly controlled conditions for people to retrieve personal possessions and valuables they left behind. These items were monitored for radioactive contamination prior to removal from the affected area.

Return

Return is simply allowing people to go back to the area to live or work. To return to an area, the radiation levels must be below the relocation dose limits (20 mSv or 2 rem in the first year, 5 mSv or 500 mrem in any year thereafter). Radiation professionals will continually re-assess the affected area for years after the incident, with the goal of identifying areas to which people can return.

People attending a public meeting

Late Phase Actions

Late phase activities have not been as clearly defined as the activities in the early and intermediate phases. This lack of clarity is largely because the United States has not experienced a radiation incident significant enough to require clear definition. Late phase activities may include the cleanup of affected sites, particularly critical infrastructure and sites that have cultural or historic significance.

A critical component in the late phase is getting all parties to agree on cleanup goals. Depending on the nature of the radiation emergency, remediating the affected area to pre-incident background radiation levels may not be feasible. Some areas may be too contaminated to go back to their original use, but radiation levels may be low enough to provide an alternate use. For example, land that is too contaminated to grow crops may be okay to use for recreational purposes. Public officials and residents will need to work together to determine the appropriate use for the land.

Notes

Notes

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention