

Guidelines for Handling Decedents Contaminated with Radioactive Materials

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Summary

During Top Off 2, an exercise involving federal agencies simulating a dirty bomb in Seattle, Washington, during May 12–14, 2002, the Disaster Mortuary Operations Response Team (DMORT) asked representatives from the Centers for Disease Control and Prevention (CDC) for guidance on handling radioactively contaminated decedents. CDC committed to issuing written guidelines for this situation. On March 9–10, 2004, CDC hosted a round table in Atlanta to review issues that should be addressed in these guidelines. Participants included health physicists, morticians, and medical examiners. All participants agreed that CDC's guidelines should address decedent operations in the field and in morgues, funeral homes, and cemeteries. The participants also agreed that the guidelines should consider religious, cultural, and communications issues.

Many scenarios could result in radioactively contaminated decedents. The most significant of these would be detonation of a nuclear weapon or activation of a radiological dispersal device. CDC's guidelines are designed to address both scenarios. They could be used for other instances in which decedents' bodies are contaminated with radioactive materials, such as reactor accidents or transportation accidents involving radioactive material. These guidelines are designed to be consistent with other U.S. Environmental Protection Agency Federal Emergency Management Agency, U.S. Department of Transportation, and Nuclear Regulatory Commission guidelines.

Introduction

A large-scale event involving the release of radioactive materials could cause many deaths, resulting in radioactively contaminated decedents. In March 2004, CDC hosted a

round table in Atlanta attended by representatives of the federal Disaster Morgue Operations Response Teams (DMORT), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Defense (DOD), the U.S. Department of Energy (DOE), medical examiners, and morticians.

The purpose of the round table was to develop guidelines for medical examiners, coroners, morticians, and cemetery operators on how to handle radioactively contaminated decedents. Participants agreed that CDC's guidelines should include steps that medical examiners, coroners, and morticians could take to reduce their risk from exposure to radiation and the risk of radioactive contamination to decedents' family members and the general public. The guidelines should also address religious, cultural, and communications issues. After publication, CDC should supplement its guidelines with fact sheets and other training materials.

Overview of the Threat

Any of a variety of scenarios could result in the release of radioactive materials. Of these, detonation of a nuclear weapon or dispersal of radioactive material with a conventional explosive are most likely to create large numbers of radioactively contaminated decedents.

Key Concepts

Radiation refers to the charged particles or electromagnetic rays emitted by *radioactive material*. *Contamination* is the presence of radioactive material in an inappropriate place. There may be absolutely no possibility of the spread of

contamination from radioactive material inside a sealed container; yet persons standing near that container will be exposed to the *radiation* from that material.

The terms *dose* and *dose rate* are used to explain the hazards of working with radioactive material. Radiation *dose* is the amount of energy from radiation absorbed by the body, not the amount of radioactive material in the body. The dose rate at a given location is the amount of energy per unit time a person standing in that location would absorb. See <http://www.bt.cdc.gov/radiation/measurement.asp> for more information about measurement of radiation.

Detonation of a Nuclear Weapon

The energy from the detonation of a nuclear weapon produces extreme heat and wind, prompt emission of high levels of radiation, and distribution of radioactive fallout. The splitting of plutonium or uranium atoms is the source of this energy. Each atom splits into two unstable, smaller, radioactive fission product atoms. These fission products produce most of the radiation in fallout.

When a nuclear weapon detonates, everything inside the fireball vaporizes. The fireball rises rapidly. The rising fireball creates the mushroom cloud associated with a nuclear detonation. As the fireball cools, the vaporized material condenses into small particles. The condensing particles trap fission products, becoming highly radioactive. The mushroom cloud contains about 90% of the radioactive fallout, and the stem of the mushroom cloud contains the remaining 10% (1).

Within 5 minutes after the explosion, the mushroom cloud stabilizes and starts to move downwind, and the particles within it begin to settle to earth. Persons within a large

area downwind of the explosion could be exposed to enough radiation from fallout to cause sickness or death within a few days.

The mixture of fission products from the weapon decays rapidly. The dose rate after a detonation can be precisely calculated using the following relationship (*D*):

$$\text{dose rate} = \text{initial dose rate} \times t^{-1.2},$$

where *t* = time in hours after detonation.

These dose rates can be estimated using the Rule of Seven, which states that the dose rate decreases by a factor of 10 for each sevenfold increase in time following a fission detonation (Table 1). The Rule of Seven applies to the mixture of short-lived fission products created by a nuclear blast. This rule is valid only for the first 2 weeks after detonation. Rain can accelerate the decrease in dose rate in a given area.

Deaths Caused by a Nuclear Weapon

The detonation of a nuclear weapon would produce both initial and delayed deaths. Initial deaths would include persons at or near ground zero killed by blast, heat, or flying objects. Delayed deaths would include:

- a. Persons who died because of injuries sustained in the initial blast;
- b. Persons who died from acute radiation syndrome caused by exposure to high levels of radioactive fallout;
- c. Persons who died from a combination of injuries and acute radiation syndrome.

Persons who die immediately because of the blast could have radioactive material on their skin and clothes as surface contamination or radioactive shrapnel embedded in

their bodies, but they will not have internal contamination from inhalation or ingestion.

Decedents contaminated by surface debris or shrapnel can be decontaminated.

Persons who die hours or days later may have inhaled or ingested radioactive material, making them internally contaminated. Internal contamination cannot be eliminated, but the dose rates from this source of contamination will be too low to pose a health risk to other persons in the vicinity of the body.

Detonation of a Radiological Dispersal Device

A radioactive dispersal device is designed to spread radioactive material and contaminate humans and the environment. Radioactive material can be spread by mechanical means, such as in a spray, or through the use of high explosives to scatter radioactive material in a device known as a dirty bomb. Unlike a nuclear weapon, the radioactive material in a dirty bomb consists of only one or two long-lived isotopes, so initial measured dose rates will persist for several days or weeks (2). The explosion from a dirty bomb would not be as powerful as that from a nuclear weapon, and it would not release as much radioactivity because the splitting of atoms does not occur.

Deaths Caused by a Radiological Dispersal Device

A radioactive dispersal device that is a mechanical spray device is not likely to cause many deaths. Immediate deaths from a dirty bomb would be caused by the blast itself, not the radioactivity. The decedents may be externally contaminated with radioactive material that can be removed by washing or with embedded radioactive shrapnel that must be surgically removed. Some victims could inhale or ingest

radioactive material from the incident and die a few days or weeks later, either from injuries caused by the blast, radiation exposure, or the combined effects of both. Internal contamination cannot be eliminated, but the dose rates from this source of contamination will be too low to pose a health risk to other persons in the vicinity of the body.

Depositing a Radioactive Source in a Public Place

A high-level radioactive source in a public place, such as a movie theatre or a city bus, could expose a large number of persons to enough radiation to cause acute radiation syndrome. The symptoms of acute radiation syndrome (skin burns, influenza-like symptoms) could take hours to weeks to develop. In general, the higher the dose the more rapid the onset and the more severe the symptoms will be. (See CDC's web site at <http://www.bt.cdc.gov/radiation/ars.asp> for more information.) Many persons could develop symptoms of acute radiation syndrome before the first deaths.

A person can be exposed to a radioactive source and become very ill or die without being contaminated with radioactive material. No special precautions are required for handling the remains of persons killed by exposure to radiation.

Principles of Radiation Protection

Medical examiner's team members can reduce their radiation exposure when handling radioactively contaminated decedents through the use of time, distance, and shielding.

- Time — the less time spent near a radioactive source, the lower the dose received;
- Distance — the further from a radioactive source, the lower the dose received;

- Shielding — the more material between a person and a radioactive source, the lower the dose received.

Ionizing radiation removes electrons from atoms. Ionizing radiation that could be present from a radiological incident includes gamma radiation, beta particles, and alpha particles. Each type of ionizing radiation has different penetrating abilities that affect its ability to cause harm.

Ionizing radiation causes two kinds of health effects: a) observable symptoms that occur soon after exposure, such as reddening of the skin, nausea, or changes in blood cell counts; and b) delayed effects, such as cancer, that might or might not occur until years after the exposure.

Large doses of radiation are necessary to cause observable symptoms. The larger the exposure, the more severe the health effects and the sooner the symptoms appear. The severity of the symptoms of acute radiation syndrome are a function of dose; and they are specific and predictable.

The probability of cancer increases with the dose. However, once cancer occurs, its severity is independent of the dose. A cancer caused by radiation is not distinguishable from any other cancer.

The precautions included in these guidelines are designed to keep the radiation dose to medical examiners, coroners, morticians, and family members of the deceased as low as reasonably achievable (ALARA) and prevent the spread of contamination. (“ALARA” is a standard acronym in the nuclear industry.

Differences Between Radiological Hazards and Chemical or Biologic Hazards (3)

- Tiny amounts of radioactive material can be detected and located with portable radiation detection equipment, whereas detection of chemical or biologic agents requires specialized laboratory testing.
- Radioactive material cannot be destroyed by chemicals or fire. Decontamination simply moves radioactive materials somewhere else. Chemical or biologic agents can be destroyed.
- Radioactive sources are not contagious. Radioactive contamination can be thought of as dirt that can be removed. Chemical agents are not contagious, although biologic agents are.
- The quantity of radioactive material always decreases over time. Chemical agents might persist, and biologic agents could multiply within a host body.
- Any outer garment will protect the wearer from alpha or beta radiation, but it will not block gamma radiation. However, coveralls will help prevent contamination from all types of radiation emitters and should be worn if any possibility exists of radioactive contamination on the decedent. Some types of protective clothing provide protection against chemical or biological agents (4).
- Respiratory protection normally used by emergency responders or embalmers reduces the risk of inhalation of radioactive particles and internal contamination with radioactive materials. Different types may or may not protect against inhalation of some biological or chemical agents (4).

- Eye protection reduces the risk for radioactive, chemical, or biologic material being absorbed by the tissues of the eyes.

Allowable Radiation Doses

The allowable radiation dose to medical examiners, coroners, morticians, and family members will depend on the situation. Two objectives should be considered when planning or directing a worker's exposure to radiation:

- a. Do not exceed a federal radiation dose limit; and
- b. Keep doses as low as reasonably achievable below regulatory limits without curtailing vital operations.

Title 10 Part 20 of the Code of Federal Regulations (10 CFR 20) limits a radiation worker's dose to 5 rem per year. (5) (There are other regulations limiting the dose to a member of the public from emissions from a nuclear power plant, or dose from standing in proximity to a nuclear medicine patient.)

Supervising medical examiners should establish an administrative limit on the dose they will allow for their team members. This dose limit should initially be set as low as reasonably achievable, without restricting essential operations. If necessary, the limit may later be increased, as long as the cumulative dose to any individual does not exceed 5 rem.

To estimate the amount of time a team member may be allowed to work in a radiologically controlled area, measure the dose rate with a survey meter and divide that number into the established dose limit. For example,

Administrative limit established per worker: 200 mrem

Area dose rate: 50 mrem per hour

Allowed stay time: $200 \div 50 = 4$ hours

Use the calculated stay times for planning purposes only. Workers should frequently check their dosimeters to determine their actual doses.

An alternative would be to limit doses to some number like 25 mrem per decedent. If the initial survey indicates a decedent cannot be completely processed without exceeding this limit, move the decedent to a refrigerator at least 10 meters from the work area and deal with it later.

Allowable Radiation Doses to the Public

10 CFR 20.1301 limits radiation exposure from emissions at a nuclear facility to a member of the public to 0.1 rem per year.⁽⁵⁾ 10 CFR 35.75 limits the exposure from a living nuclear medicine patient to a member of the public to 0.5 rem. ⁽⁶⁾ No regulation is that governs exposure of a member of the public from a radioactive decedent. CDC recommends taking all reasonable measures to keep exposures to the public as low as reasonably achievable, with an upper limit of 0.1 rem per year.

Instrument Needs

Dealing with a radiological hazard safely is not possible without proper instruments used by trained operators. Medical examiners, coroners, or morticians may not want to obtain their own equipment because of the initial expense, the need for extensive training,

and the continuing financial and administrative burden of keeping the instruments calibrated. CDC recommends that all medical examiners, coroners and morticians develop a contingency plan. This may require a partnership agreement with local trained first responders, the state Radiation Control Program Director, a local hospital with a Health Physics or Nuclear Medicine Department, a local nuclear power plant, or a local facility that uses radioactive materials for research or industrial applications. Surveying and decontaminating decedents will not be as time sensitive as dealing with live people or the environment, so refrigerating the decedents until technical assistance is available should be part of the plan.

[Figure 1](#) shows a CV-700, the most common instrument in the country. A CV-700 is a low-range Geiger Mueller (GM) instrument that measures gamma radiation. [Figure 2](#) shows a Ludlum kit with a high-range GM probe, a low-range GM pancake probe, and a sodium iodide probe. The sodium iodide probe and high-range GM probe can only detect gamma radiation. The pancake probe can read alpha, beta, and gamma radiation and is the instrument of choice for initial surveys of decedents because it is a directional probe.

The sodium iodide or low-range GM probe is the instrument of choice for team members making initial entry into an area that has fairly low radiation levels, because these probes are omnidirectional. Initial entry into areas that have high radiation levels requires use of the GM probe, because sodium iodide detectors may fail to respond properly.

At the morgue, CDC recommends as a minimum a CDV-700 or newer instrument with a Geiger-Mueller (GM) pancake probe ([Figures 2 and 3](#)). Guidelines provided below for use of this probe are valid for the mix of radionuclides that would be expected after a

reactor accident or detonation of a nuclear weapon. (7) If the radioactive material is from another source, a health physicist or equipment vendor should suggest alternative guidelines to correct for the type and energy of the radiation being measured.

Radiation detection equipment requires regular quality control and maintenance. If medical examiners, coroners, or morticians decide to purchase such equipment for themselves, some staff members will have to be trained on its proper use and maintenance. The training should include annual refresher courses. Detectors must be serviced and recalibrated annually to ensure proper operation.

Operations at the Scene and in the Field Morgue

Firefighters, police officers, and emergency medical technicians will act as needed to protect property and save lives. While this work is in progress, medical examiners or coroners should prepare a safety plan for their operations, issue personal dosimeters to everyone working in the area, establish a registration system for recording cumulative doses, and brief all team members on the plan. Emergency plans should include using a health physicist in preparing the safety plan and conducting training. In addition to the normal information included in the safety briefing, training for entering a radiologically controlled area should include:

- The basics of radiation protection,
- Expected dose rates and stay times in different areas,
- Use of dosimetry and radiation detection equipment, and
- The hazards associated with different radiation doses.

In addition to the information normally included in a safety plan, the plan should include

- Provision of self-reading dosimeters (Figures 5 and 6) to team members,
- Dose limits for workers,
- A schedule for rotating team members to keep doses within limits,
- Tagging requirements for human remains and body bags, and
- A procedure for recording measured doses to workers.

The safety plan and training normally includes other issues, such as heat stress or fire safety. These guidelines address only radiological aspects of the casualty.

Procedures at the Incident Scene

Officials should cordon off the boundaries of the contaminated area and assign a person (called a “control point watch” in nuclear facilities) who will:

- Control access to the area.
- Maintain a record of each person entering the area, including name, time in, dosimeter reading in, time out, and dosimeter reading on egress.
- Ensure that dosimeters are outside the clothing or PPE where they can be read.
- Ensure that everyone entering the area has received the safety briefing.
- Ensure that everyone entering the area reviews the radiation survey map after the initial entry team has created the map.
- If a communication system is available, remind all persons to read their dosimeters at regular intervals while they are in the radiologically controlled area.

Radiation control technicians should make the initial entry, survey the area using omnidirectional probes on their meters, prepare a map showing dose rates in different

areas, and post a copy of the map beside the Control Point Watch. No one should enter the area to begin decedent recovery until this survey is complete. The medical examiner's or coroner's team members entering the area should be equipped with personal dosimeters, and their stay times should be planned to keep the total dose to each worker below the established administrative exposure limit.

Recovery of Decedents from the Scene

The time frame in which bodies can be removed from the scene of a radiological incident differs according to type of event. It may be desirable to delay the recovery of bodies from the site of a nuclear weapon detonation, because most of the radioactive fission products decay rapidly, thus reducing the exposure rate and increasing the allowable stay time. However, radioactive material from a radiological dispersal device will probably remain constant for days or weeks, so there is no benefit to the delay of recovery operations after detonation of a radiological dispersal device. Medical examiners or coroners must decide when to recover the decedents and the appropriate stay times for workers at the incident scene.

Radiation survey team members or other first responders should not disturb a body without permission from the medical examiner or coroner. Preservation of evidence and identification of victims are paramount. Do not remove clothing from bodies at the scene even if this would reduce the radioactive material delivered to the morgue.

After the medical examiner or coroner authorizes removal of bodies, survey each body. To survey a body using a pancake probe, hold the probe 1–3 inches from the body and move it at a rate not exceeding 6 inches per second. If the count rate from a body

exceeds 300 counts per minute, place a radioactive warning tag on the body and another one on the outside of the body bag before sending it to the morgue. For other instruments, conduct the survey using the guidelines in [Table 2 \(7\)](#).

Procedures in the Morgue

A field morgue should be established near the scene, but in an area where dose rates are low. Take background readings with all available instruments before receiving the first bodies. Record the results for each instrument.

Bodies arriving at the morgue may contain embedded and highly radioactive shrapnel, low-level loose surface contamination, low-level internal contamination, or no contamination. The morgue should set up a clean processing line, a contaminated processing line, and a refrigeration facility at least 10 meters (33 feet) from these two work areas.

Use a pancake probe to survey the decedents as they arrive. Hold the probe 1–3 inches above the body and move it at a rate of 6 inches per second or less. The survey of each body should take at least 4 minutes. For other instruments, conduct the survey using the guidelines in [Table 2 \(7\)](#). Consider bodies reading less than 300 cpm as uncontaminated and send them to the clean line; send bodies reading greater than 300 cpm above the background level to the contaminated line [\(7\)](#). Send bodies that exceed the range of the pancake probe or that read greater than 100 mrem/hr on contact with a GM counter to the refrigeration facility until a special procedure can be created for handling them. 100 millirem per hour is a suggested number. Supervisors may wish to set a lower

limit to minimize the doses to the morgue staff if a large number of highly radioactive bodies are expected.

A typical medical examiner's team consists of two medical examiners, a photographer, and a scribe. They should examine the body and then carefully remove and bag all clothing and jewelry, documenting and photographing each step. Typical personal protective measures—wearing coveralls, gloves, a particulate respirator, and goggles and bagging all removed clothing— will adequately protect the team and prevent the spread of contamination. Bagged clothing should be labeled as radioactive if it measures greater than 300 counts per minute using a pancake probe held 1–3 inches from the bag. For other instruments, use the guidelines in [Table 2 \(7\)](#).

After processing each group of decedents (or every 4 hours if operations are continuous), survey the field morgue and clean up any contamination. This will decrease the spread of contamination and prevent incorrect labeling of uncontaminated bodies as contaminated.

After bodies have been released by the morgue team, they can be moved to a decontamination area and washed. Collection of runoff is not necessary for uncontaminated bodies. Collect the runoff from contaminated bodies for later disposal as low-level waste.

After washing a decedent and removing any radioactive shrapnel, perform a last survey. Release the body for burial without restrictions if readings are less than 5,400 counts per minute (cpm) with a pancake probe on a CV-700 or less than 36,000 cpm with a pancake probe on a modern instrument [\(7\)](#). If readings are higher than these levels,

attach a tag to the body indicating the date, dose rate, distance at which this dose rate was measured, and the equipment used to perform the measurement.

Autopsies

Do not perform autopsies on internally contaminated bodies unless absolutely necessary. The pathologist performing the autopsy may receive a significant dose of radiation to the hands. If an autopsy is necessary, refrigerate the decedent and defer the procedure until a health physicist can assist in planning.

Shipping Contaminated Remains

Morticians are familiar with the requirements for shipping bodies across state lines and can assist in determining when and if they can be shipped. Licensees of radioactive sources are familiar with the regulations for shipping radioactive material across state lines (8). Regulations have not been established that address shipment of radioactive material inside radioactively contaminated decedents.

Decedents are usually embalmed and shipped in a sealed container. The two types of container most often used for this purpose are the BioSeal or the Ziegler. Either of these containers will prevent release of radioactive material to the environment, so no additional precautions are required for shipping radioactive remains. Label the outside of the shipping container in accordance with 49 CFR 172 for shipping radioactive material (8).

Procedures at the Funeral Home

The radiation dose to morticians can be minimized by burying decedents without embalming. Radiation doses to family members of decedents can be eliminated by conducting a memorial service without the body. However, emotional, religious, and cultural factors must be considered. If the family requests a funeral with a viewing, explain the potential risks to the decedent's family members on the potential risks, then recommend a closed-coffin service. For advice or technical assistance, the mortician can contact the following:

- CDC's National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Radiation Studies Branch at (404) 498-1800;
- Radiological Emergency Assistance Center Training Site (REAC/TS) at (865) 576-1005; or
- The appropriate state Radiation Control Program Director. Telephone numbers are listed on the Conference of Radiation Control Program Directors (CRCPD) web site at <http://www.crcpd.org/Map/map.asp>

Embalming Considerations

Burial without embalming and a memorial service without a viewing will minimize the radiation doses to the mortician and the family members. This may not be acceptable for religious, cultural, or emotional reasons. Embalming is required if a viewing or an open casket funeral service is to be held. The guidelines for medical examiners recommend that a body released from the morgue have no loose surface contamination or removable shrapnel, so the only source of potential radiation exposure to the family would be from internal contamination. The potential exposure to another person from a body with internal contamination is small.

Internal contamination in a living person results from inhalation or ingestion. Internal contamination in a body cannot build up after death occurs. Radioisotopes ingested or inhaled reside in the gastrointestinal tract or lungs, where they are absorbed by the blood stream and transported to an organ or muscle tissue, where they are retained until they decay or are removed by metabolic processes. At any given time the amount of radioisotope in the blood is extremely small. Most of the radioactive material will be in the lungs or gastrointestinal tract if death occurred within a day after exposure, and in body tissue if death occurred a few days after exposure.

During embalming, an incision is made above the collar bone and canulas (Figure 7) are inserted into the carotid artery and jugular vein. A compressor forces embalming fluid into the artery, and blood is drained from the vein onto a tilted embalming table (Figure 8). The blood drains down the table through a hose into a catch tank and is flushed into the sewer system. The procedure can be done with a body that has internal radioactive contamination, because blood is the only fluid being disposed.

The embalmer then inserts a trocar (Figure 9) into the lungs and gastrointestinal tract to remove all fluids retained. The material removed in this step should be retained for disposal as potentially low-level radioactive material.

CDC recommends that medical examiners establish a field morgue in the vicinity of the hazardous event to eliminate the need to transport contaminated decedents over long distances. Establishing an embalming facility adjacent to the field morgue would eliminate any concerns over processing radioactively contaminated decedents in funeral homes.

Cremation

Internally contaminated decedents should not be cremated because radioactive contamination of the facility and environment is highly likely. Cases are documented of crematories and surrounding areas becoming contaminated after the incineration of decedents who had been injected with radionuclides for nuclear medicine procedures. Because isotopes used in nuclear medicine are short-lived, these contamination incidents were not serious; however, long-lived radioisotopes that could contaminate victims of a nuclear incident could cause extensive contamination requiring extensive decontamination.

Funeral Services

Family members may be allowed to view or even touch the decedent's body at the funeral service, but they should be made aware that they will be exposed to a small amount of radiation. There will be no risk of spread of contamination. The funeral director could further reduce any possible dose by placing a velvet rope around the casket to maintain a distance of about 2 feet between the viewers and the casket. The funeral director, with advice from CDC or a state health physicist, will have to put into perspective the estimated exposures for the bereaved family members.

CDC's guidelines recommend that medical examiners attach a tab showing dose rate on contact when they release a body that has internal contamination. Dose rate is measured in millirem (mrem) per hour. Chest and dental x-rays deliver 20 millirem and 3 millirem, respectively. Funeral directors can compare the estimated doses to family

members to these common medical procedures for family members concerned about their exposure to radiation.

Example:

Dose rate at 1 foot from the body = 0.5 millirem/hour.

0.5 millirem per hour \times 2 hours = 1 millirem

Dental x-ray = 3 millirem

In this example, a family member standing 1 foot from the body for 2 hours will receive one-third the radiation of a dental x-ray. Funeral directors can use Table 3 to put the estimated doses to family members into perspective, or they can contact the nuclear medicine department of a nearby hospital, their state radiation control program director, REAC/TS, or CDC for more information.

Burial

Burial of a body that has internal contamination constitutes minimal health risk to humans or the environment, even if no special precautions are taken. Minimizing release of radioactive material into the environment is good practice, even if the amounts are very small.

A wooden casket or coffin is not sealed against elements entering or exiting the container. A metal casket has a seal that keeps gases and liquids from entering the container and keeps liquids from exiting the container.

A vault may be made of metal or concrete. Concrete vaults are lined with plastic. A vault might be constructed as a dome resting on a flat base or as a container with a lid. Both types are sealed. The latter type is recommended because it forms a better seal. The

lid should be placed on the casket before it is lowered into the ground to ensure a tight seal. A metal casket inside a vault with a seal of the type shown in [Figure 10](#) is recommended.

Religious and Cultural Considerations

Respect for the religious and cultural traditions of persons dealing with the death of family members is important. These traditions may include ritual washing or specific preparation of the body. If the medical examiner or coroner removed all loose surface contamination and shrapnel before releasing the body to a funeral director, the dose to the family member or religious leader performing the ritual will be no more than the doses to family members from a viewing as described above. There is no reason to prohibit these traditions provided the funeral director, family, and religious leader understand the minor risks involved. Morticians can contact CDC's Radiation Studies Branch (404-498-1800), the Radiological Emergency Assistance Center Training Site (REAC/TS at 865-576-1005), or the applicable state radiation control program director for advice or technical assistance.

Risk Communication

One of the most difficult communication challenges will be helping the affected persons understand the risks associated with radiation exposure. When explaining the risks to families of contaminated decedents, avoid the use of adjectives such as *safe* or *dangerous*. Quantitative information is defensible; adjectives are not. There is a theoretical and calculable *risk* from a chest x-ray; yet no radiologist would ever describe

a chest x-ray as *dangerous*. CDC recommends using the information from Table 3 to put projected radiation exposures into perspective.

Planning and Training

Regional emergency planners should include medical examiners, coroners, and morticians in their planning efforts. Medical examiners, coroners, or morticians can contact their state radiation control program director to determine what local resources are available for technical assistance on dealing with radiation during an emergency. Local resources might include staff from a nuclear power plant, the nuclear medicine department of a hospital, or state or federal response teams.

Medical examiners, coroners, and morticians should request both classroom training and participation in exercises to aid in preparedness for a radiological event. These added skills can be valuable not only in a radiological emergency, but also for everyday operations in the event a decedent has had a radioactive drug administered for a nuclear medicine procedure or received a radioactive implant.

Additional Resources

Medical examiners, coroners, and morticians, can contact the radiation control program director of the state in which they operate for more information. Use the directory at the Conference of Radiation Control Program Directors Web site (<http://www.crcpd.org>).

CDC also provides useful reference material on radiation emergencies at <http://www.bt.cdc.gov/radiation/index.asp>. CDC also has a 24 hour telephone number at 1-800-CDC-INFO.

The U.S. Department of Energy has a 24-hour emergency response center at the Radiological Emergency Response Center/Training Site (REAC/TS). Call 1-865-576-1005 and ask for REAC/TS. Visit the REAC/TS Web site at <http://www.ornl.gov/reacts/> to determine availability of training courses for emergency responders.

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TABLE 1. Rule of Seven for radiation dose rates

Elapsed time	Percentage of initial radiation dose rate remaining
0 hour	100.0
7 hours	10.0
49 hours (2 days)	1.0
343 hours (14 days)	0.1

TABLE 3. Examples of radiation doses from everyday sources

Examples of Radiation Doses	Dose in millirad
1 year of gas range use	4
1 hour airline flight above 30,000 feet	3
1 year of living in Maryland	15
1 year of living in Colorado	65
1 chest x-ray	20
1 year of exposure to naturally occurring radioactive material in the human body	40
1 year of exposure to background radiation (all sources)	300
1 year regulated limit to a member of the public	500
1 year regulated occupational limit	5,000
Threshold for acute radiation syndrome	50,000
50% fatality dose	500,000

TABLE 2. Recommended parameter values for detecting radioactive contamination on individuals*

Instrument/detector combination	Parameter values for detecting spot or widespread contamination on bodies			Estimated time to monitor an adult (minutes)
	Probe speed (inches/second)	Height of probe (inches)	Path width (inches)	
CD V-700 with side window detector [†]	4	0.25–0.5	0.6	19
CD V-718 with end window detector	3	0.5–1	1	12
All tested instruments with pancake detectors, except the Victoreen 190	6	1–3	2	3.9
Victoreen 190 with pancake probe [†]	6	1–4	3	2.6

*These values are based on the ability to detect 0.1 μ Ci (microcurie) of contamination on a small spot of skin in background gamma radiation levels up to 0.1 millirads per hour, except as noted. Refer to Table 4 of the [FEMA-REP-22 Background Information Document \(9\)](#) for a more detailed description.

[†]Audible detection is not possible in a background gamma radiation level of 0.1 millirads per hour. Values are for use in background levels of 0.02 millirads per hour or lower.

FIGURE 1. A CV-700 with a Geiger counter (GM) omnidirectional probe



FIGURE 2. The Ludlum 2241-3 ratemeter with a high range GM probe, a GM pancake probe, and a sodium iodide probe



FIGURE 3. Close-up view of a pancake probe



FIGURE 4. A sodium iodide scintillation probe



FIGURE 5. A Bicron ratemeter and dosimeter



FIGURE 6. Direct reading dosimeter



FIGURE 7. Canulas



FIGURE 8. Preparation table used during embalming



Figure 9 – Trocar



FIGURE 10. Recommended vault seal

