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Standard Practice for Radiological Emergency Response[1]

This standard is issued under the fixed designation E2601; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

One of the legacies of the Oklahoma City bombing and the attacks of September 11, 2001 is recognition that terrorists use weapons of mass destruction (WMD). This awareness has changed the philosophy of emergency response across disciplines. Incident response is still based on accepted procedures and safe work practices developed over the years, but the new mission must include concerns that are specific to an intentional release of hazardous materials designed to kill or injure and cause destruction of property. This standard practice provides guidance for responding to incidents where radioactive materials might be used with that intent. The standard also applies guidance for general radiological emergency response. The purpose of the guidance is to save lives, minimize radiation dose, and move members of the public out of perceived danger areas.

This standard practice provides decision making considerations that jurisdictions can use to respond to incidents that involve radioactive materials. The standard practice provides a consistent set of practices that can be incorporated into the development, planning, training, and implementation of guidelines for radiological emergency response. The standard practice does not incorporate long-term recovery or mitigation considerations, nor does it include provisions for improvised nuclear device[2] (INDs) detonations or nuclear power plant (NPP) accidents. Jurisdictions using the standard practice shall incorporate their own procedures for notification and requests for assistance from specialized radiological response assets.

The following are key concepts associated with this standard practice:

The standard practice applies to the emergency phase of an event (0 to 24 h or until specialized resources arrive on scene if they are requested).

It adheres to a risk-based response; this means the guidance presented is intended to be coupled with the authority having jurisdiction's (AHJ's) understanding of local vulnerability and capability when developing its plans and guidance documents on the subject.

It is compliant with the National Incident Management System (NIMS) and uses Incident Command System (ICS) common terminology. Full compliance with NIMS is recognized as an essential part of emergency response planning. In developing this standard practice, every effort was made to ensure that all communications between organizational elements during an incident are presented in plain language according to NIMS 2007. In keeping with this NIMS requirement, key definitions and terms, using plain English, are incorporated.

It is not intended for large-scale nuclear scenarios (for example, IND), which may quickly exhaust the capabilities of local emergency responders.

The standard practice is not intended to prepare communities for nuclear power plant accidents. The state of preparedness for communities in close proximity to nuclear power plants far exceeds the minimum requirements and capabilities described in this standard practice.

TRACEM (Thermal, Radiological, Asphyxiant, Chemical, Etiological, Mechanical) issues were considered throughout. While response to radiological hazards is the focus of this standard practice, responders must consider all hazards during a response; it is possible that non-radiological hazards may present a greater danger at an incident.

The standard practice does not address airborne contamination levels of radioactive materials exposure. Equipment to determine this potential hazard is not widely available in emergency responder communities. Respiratory protection is required for emergency responders until a complete hazard identification assessment is complete.

1. Scope

1.1 This practice provides decision-making considerations for response to incidents that involve radioactive materials. It provides information and guidance for what to include in response planning, and what activities to conduct during a response. The scope of this standard practice does not explicitly consider response to INDs or nuclear power plant accidents.[3] It does not expressly address emergency response to contamination of food or water supplies.

1.2 This practice applies to those emergency response agencies that have a role in the response to a radiological incident, excluding an IND incident. It should be used in emergency services response such as law enforcement, fire department, and emergency medical response actions.

1.3 This practice assumes that implementation begins with the recognition of a radiological incident and ends when emergency response actions cease or the response is assumed by specialized regional, state, or federal response teams.

1.4 AHJs using this practice will identify hazards, develop a plan, acquire and track equipment, and provide training consistent with the descriptions provided in Section 6. AHJs not able to meet the requirements should refer to the United States (US) Department of Transportation (DOT) Emergency Response Guidebook (ERG) for guidance on how to manage radiological incidents (DOT, current version). This standard practice provides additional guidance and is not intended to replace the ERG, rather to supplement it (see Annex A1[4]).

1.5 *This standard practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard practice to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *Referenced Standards and Documents:*

ANSI N42.33 American National Standard for Portable Radiation Detection Instrumentation for Homeland Security[5]

ANSI N42.32 American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security[5]

ANSI N42.49A American National Standard for Performance Criteria for Alarming Electronic Personal Emergency Radiation Detectors (PERDs) for Exposure Control[5]

CDC 2007 Population Monitoring in Radiation Emergencies: A Guide for State and Local Public Health Planners[6]

CRCPD 2006 Radiological Dispersal Device (RDD)—First Responder's Guide, the First 12 Hours[7]

CTOS 2014 WMD Definitions for Use in the DHS Course Materials Developed by CTOS[8]

29 CFR 1910 Occupational Safety and Health Standards[9]

49 CFR 173 Shippers General Requirements for Shipments and Packages[9]

DOT, current version, Emergency Response Guidelines (ERG)[10]

EPA 400-R-92-001 Manual of Protective Action Guides and Protective Actions for Nuclear Incidents[11]

EPA PAG Manual Protective Actions Guides and Planning Guidance for Radiological Incidents, 2013 (Draft for Interim Use and Public Comment)[11]

EPA-402-F-07-008 Communicating Radiation Risks, Office of Radiation and Indoor Air[11]

FEMA 2008 Application of Protective Action Guides for Radiological Dispersal Device (RDD) and Improvised Nuclear Device (IND) Incidents[12]

Homeland Security Act of 2002 [13]

IAEA 2006 Manual for First Responders to a Radiological Emergency[14]

ICRP Publication 96 Protecting People against Radiation Exposure in the Event of a Radiological Attack, 96[15]

NCRP Commentary No. 19 Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism[16]

NCRP Report No. 138 Management of Terrorist Events Involving Radioactive Material[16]

NCRP Report No. 116 Limitation of Exposure to Ionizing Radiation[16]

NCRP Report No. 165 Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers[16]

NFPA 472 Standard for Professional Competence of Responders to Hazardous Materials Incidents[17]

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[1] This practice is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.02 on Emergency Preparedness, Training, and Procedures.

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[2] An improvised nuclear device is defined as follows: A device incorporating fissile materials designed or constructed outside of an official government agency and that has, or appears to have, or is claimed to have the capability to produce a nuclear explosion. It also may be a nuclear weapon that is no longer in the custody of competent authority or custodian, or has been modified from its designated firing sequence, or it may have been assembled from illegally obtained nuclear weapons components or special nuclear materials.

[3] Local response to nuclear facilities incidents should follow nuclear facility plans, especially in accordance to ingestion pathway zone actions, such as distribution of potassium iodine.

[4] Annex A1 material is labeled to complement the standard practice section numbers and can be found at the end of the standard before the appendices. The annex provides additional information for responder consideration.

[5] Available from http://standards.ieee.org/getN42/.

[6] For access to document, go to http://www.bt.cdc.gov/radiation/pdf/population-monitoring-guide.pdf.

[7] For access to document, go to http://www.crcpd.org/publications.asp#RDD.

[8] For access to document, go to www.ctosnnsa.org.

[9] For access to document, go to www.access.gpo.gov.

[10] Available from http://hazmat.dot.gov/pubs/erg/gydebook.htm.

[11] Available from www.epa.gov.

[12] Available from http://edocket.access.gpo.gov/2008/E8-17645.htm.

[13] For access to document, go to http://www.whitehouse.gov/deptofhomeland/bill/hsl-bill.pdf.

[14] For access to document, go to http://www-pub.iaea.org/MTCD/publications/PDF/EPR_FirstResponder_web.pdf.

[15] For access to description and site for ordering, go to http://www.elsevier.com/wps/find/bookdescription (cws_home/707248/description#description).

[16] Available from www.ncrponline.org.

[17] Available from www.nfpa.org.

NIMS 2007 Draft revised NIMS for interim use[18]

NRF 2008 [19]

NIST 2006a Results of Test and Evaluation of Commercially Available Survey Meters for the Department of Homeland Security—Round 2[20]

NIST 2006b Results of Test and Evaluation of Commercially Available Personal Radiation Detectors (PRDs) and Radiation Pagers for the Department of Homeland Security—Round 2[20]

NIST 2005a Results of Test and Evaluation of Commercially Available Survey Meters for the Department of Homeland Security[20]

NIST 2005b Results of Test and Evaluation of Commercially Available Personal Radiation Detectors (PRDs) and Radiation Pagers for the Department of Homeland Security[20]

NUREG-0654/FEMA-REP-1, Rev. 1 Addenda Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, Final Report[21]

NUREG-0654/FEMA-REP-1 Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants[21]

3. Terminology

3.1 *Definitions:*

3.1.1 *authority having jurisdiction (AHJ)*—the organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure. **NFPA 472**

3.1.2 *ALARA (as low as reasonably achievable)*—a principle of radiation protection philosophy that requires that exposures to ionizing radiation should be kept as low as reasonably achievable, economic and social factors being taken into account; the ALARA principle is satisfied when the expenditure of further resources would be unwarranted by the reduction in exposure that would be achieved. **NCRP Report No. 165**

3.1.3 *committed effective dose equivalent (CEDE)*— committed effective dose equivalent is the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

3.1.4 *decision points*—predefined exposure rates or doses at which a decision-maker must determine a path forward to maximize responder safety and public protection.

3.1.5 *decontamination*—(*1*) the removal of radionuclide contaminants from surfaces (for example, skin) by cleaning and washing (NCRP Report No. 165); (*2*) the physical or chemical process of reducing and preventing the spread of contaminants from people, animals, the environment, or equipment involved at hazardous materials/weapons of mass destruction (WMD) incidents (2013 Edition NFPA 472 3.3.17).

3.1.6 *defensive operation(s)*—emergency response measures taken from a safe distance (for example, outside the hot zone) to prevent or limit radiation exposure or the spread of hazardous material; life-safety operations are not a concern if defensive operations are the only operations supporting the response.

3.1.7 *dose*—radiation absorbed by an individual's body; general term used to denote mean absorbed dose, equivalent dose, effective dose, or effective equivalent dose, and to denote dose received or committed dose; see Total Effective Dose Equivalent (TEDE). **CRCPD 2006**

3.1.8 *dosimeter*—a small portable instrument (such as a film badge, thermoluminescent dosimeter, or pocket dosimeter) used to measure and record the total accumulated personal dose of ionizing radiation. **U.S. NRC Glossary**

3.1.9 *emergency decontamination*—the physical process of immediately reducing contamination of individuals in potentially life-threatening situations with or without the formal establishment of a decontamination corridor. A goal of emergency decontamination is reducing dose to a lower level; however it may not be possible to completely eliminate contamination.

3.1.10 *emergency operations center (EOC)*—the physical location at which the coordination of information and resources to support incident management activities normally takes place. An EOC may be a temporary facility or in a permanently established location in a jurisdiction. **NIMS 2007**

3.1.11 *emergency responder*—emergency response providers include federal, state, and local government, fire, law enforcement, emergency medical, and related personnel, agencies, and authorities. **Homeland Security Act of 2002**

3.1.12 *emergency response*—the performance of actions to mitigate the consequences of an emergency for human health and safety, quality of life, the environment and property. It may also provide a basis for the resumption of normal social and economic activity. **IAEA 2006**

3.1.13 *evacuation*—organized, phased, and supervised withdrawal, dispersal, or removal of civilians from dangerous or potentially dangerous areas, and their reception and care in safe areas. **NIMS 2007**

3.1.14 *high exposure rate*—exposure rate beyond which emergency response is not recommended for rescue operations unless the incident commander (IC) determines it can be carefully controlled for a short duration for priority operations such as life-saving, and the emergency responder is informed of the hazards and consents to performing the operation(s); the recommendation of this standard practice is for a high exposure rate less than or equal to 100 R/h (1 Sv/h). For the purposes of this standard practice, the term "high dose rate" is equivalent to "high exposure rate."

3.1.15 *hot zone*—the control zone immediately surrounding a hazardous materials incident, which extends far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. **NFPA 472**

3.1.16 *hot line*—the line of demarcation that may become a decision point to control the hot zone; for a radiological response, the hot line shall correspond to a previously established exposure rate (for example, the low exposure rate) or

[18] For access to document, go to www.fema.gov.

[19] For access to document, go to www.dhs.gov.

[20] For permission to access document, go to https://www.rkb.us/.

[21] For access to document, go to www.nrc.gov.

contamination level above which personnel shall be trained and protected appropriately by personal protective equipment (PPE) to operate. The location of the hot line may not be determined based on radiation exposure rate or contamination level if a higher hazard associated with the incident presents greater risk.

3.1.17 *improvised nuclear device (IND)*—a device incorporating fissile materials designed or constructed outside of an official government agency and that has, or appears to have, or is claimed to have the capability to produce a nuclear explosion. It also may be a nuclear weapon that is no longer in the custody of competent authority or custodian, or has been modified from its designated firing sequence, or it may have been assembled from illegally obtained nuclear weapons components or special nuclear materials. **CTOS 2014**

3.1.18 *incident commander (IC)*—the individual responsible for all incident activities, including the development of strategies and tactics and the ordering and release of resources. The IC has overall authority and responsibility for conducting incident operations and is responsible for the management of all incident operations at the incident site **NIMS 2007**

3.1.19 *jurisdiction*—a range or sphere of authority. Public agencies have jurisdiction at an incident within their area of responsibility. Jurisdictional authority at an incident can be political, geographic (for example, city, county, tribal, state, or federal boundary lines) or functional (for example, law enforcement, public health). **NIMS 2007**

3.1.20 *low exposure rate*—the radiation exposure rate that marks the hot line if the radiation exposure hazard poses the greatest risk at an incident. It is recommended that the low exposure rate not exceed 10 mR/h (milliR/h) (0.1 mSv/h (milliSv/h)) at 1 m (3.3 ft) from the object or at 1 m (3.3 ft) above the ground or surface. For the purposes of this standard practice, the term "low dose rate" is equivalent to "low exposure rate."

3.1.21 *multiagency coordination system (MACS)*— a system that provides the architecture to support coordination for incident prioritization, critical resource allocation, communications systems integration, and information coordination. The elements of the MACS include facilities, equipment, personnel, procedures, and communications. An EOC is a commonly used element. These systems assist agencies and organizations responding to an incident. **NIMS 2007**

3.1.22 *offensive operation(s)*—emergency response measures taken to reduce or minimize exposure from hazardous circumstances and materials to responders and civilians (for example, operations required within the hot zone); life-safety operations are top priority in offensive operations however evidence preservation shall be considered.

3.1.23 *orphan source*—a radioactive source that is not under regulatory control, either because it has never been under regulatory control, or because it has been abandoned, lost, misplaced, stolen, or transferred without proper authorization. **ICRP Publication 96**

3.1.24 *personal emergency radiation detector (PERD)*—an alarming electronic radiation measurement instrument used to manage exposure by alerting the emergency responders when they are exposed to gamma radiation. The instrument provides rapid and clear indication of the level of radiation exposure (dose) or exposure rate (dose rate), or both, and readily recognizable alarms. The alarms are both audible and visual, and distinguishable between exposure rate and exposure. **COTS 2014**

3.1.25 *personal protective equipment (PPE)*—the equipment provided to shield or isolate a person from hazards (TRACEM) that can be encountered at hazardous materials/WMD incidents. **NFPA 472**

3.1.26 *personal radiation detector (PRD)*—a pocket-sized detection instrument worn by an operator to detect the presence of radiological/nuclear material in a limited area in the vicinity of the operator. PRDs detect small increases in gamma radiation above background levels and alert the operator. Some models have additional capabilities to measure gamma radiation exposure rate levels, measure the accumulated gamma radiation dose, or a limited capability to detect neutron radiation, or combinations thereof. **CTOS 2014**

3.1.27 *preventive radiological/nuclear detection (PRND) or Radiological/Nuclear Detection (RND)*—capability to detect, illicit radiological/nuclear materials and radiological/nuclear WMDs at the points of manufacture, transportation, and use, and to identify the nature of material through adjudication or resolution of the detection alarm. This does not include actions taken to respond to the consequences of the release of radiological/nuclear materials (such as response to the detonation of a Radiological Dispersal Device). Also called Preventative Radiological/Nuclear Detection (PRND) **CTOS 2014**

3.1.28 *radiological dispersal device (RDD)*—any device that intentionally spreads radioactive material across an area with the intent to cause harm, without a nuclear explosion occurring. An RDD that uses explosives for spreading or dispersing radioactive material is called an "explosive RDD." The term "dirty bomb" is used by media, government, and others as a well-known, non-technical term for an explosive RDD. Non-explosive RDDs could spread radioactive material using common items such as pressurized containers, fans, building air-handling systems, sprayers, crop dusters, or even spreading by hand. **CTOS 2014**

3.1.29 *radiation exposure device (RED)*—a device intended to cause harm by exposing people to radiation without spreading radioactive material. An example of a RED is unshielded or partially shielded radioactive material placed in any type of container and in a location capable of causing a radiation exposure to one or more individuals. Also called a "Radiological Exposure Device (RED)." **CTOS 2014**

3.1.30 *rem*—a unit of biological/risk equivalent dose; not all radiation produces the same biological effect, even for the same amount of absorbed dose; rem relates the absorbed dose in human tissue to the effective biological damage of the radiation. For the purpose of this standard practice, the 1 rem of dose is equal to 10 mSv.

3.1.31 *roentgen (R)*—a unit of exposure to ionizing radiation. It is the primary standard of measurement used in the emergency responder community in the United States. For the purpose of this standard practice, 1 R of exposure is equal to 1 rem and 10 mSv of dose to the human body.

1000 micro-roentgen (microR or uR) = 1 milli-roentgen (mR)
1000 milli-roentgen (mR) = 1 roentgen (R), thus
1 000 000 microR = 1 roentgen (R)

3.1.31.1 *Discussion*—To improve clarity in communications, the unit roentgen may be spoken as "R" instead of pronouncing "roentgen." The SI prefix "micro" (one millionth) may be written as a lower case "u" or the phrase "micro" instead of the lower case Greek letter mu (μ) and may be spoken as either "micro" or "U." Similarly, the SI prefix "milli" (one thousandth) may be written as either "milli" or "m" and spoken as either "milli" or "M." For example, the value of 25 μR may be written as "25 uR" or "25 microR" and pronounced as "25 U-R" or "25 micro-R." Likewise, the value of 2 mR could be spoken as "2 M-R" or "2 milli-R."

3.1.32 *roentgen per hour (R/h)*—a unit used to express exposure per unit of time (exposure rate). For the purpose of this standard practice, the roentgen unit of exposure is assumed to be equivalent to the sievert unit of dose and "1 R = 10 mSv" will be applied as the basis for comparison of traditional and SI units. For the purpose of this standard practice, the term "dose rate" is equivalent to "exposure rate."

3.1.33 *secondary threats*—any object or person(s) designed to cause harm to persons responding to an incident (emergency responders) or to increase the number of civilian casualties. Secondary threats are normally designed to cause harm after persons have responded to the scene.

3.1.34 *shelter in place*—taking shelter inside a structure and remaining there until the danger passes. Sheltering in-place is used when evacuating the public would cause greater risk than staying where they are, or when an evacuation cannot be performed.

3.1.35 *technical decontamination*—the process designed to remove hazardous contaminants from responders and their equipment and victims. It is intended to minimize the spread of contamination and ensure responder safety. Technical decontamination is normally established in support of emergency responder entry operations at a hazardous materials incident, with the scope and level of technical decontamination based upon the type and properties of the contaminants involved. In non life-threatening contamination incidents, technical decontamination can also be used on victims of the initial release. **NFPA 472**

3.1.36 *termination*—termination in the context of this standard practice is the end of life safety operations, investigative work, and assurance of protective measure implementation. This will include documentation of hazards present and conditions found.

3.1.37 *TRACEM*—the acronym for additional hazards which may be found at any incident; derived from thermal, radiological, asphyxiant, chemical, etiological, and mechanical harms.

3.1.38 *total effective dose equivalent (TEDE)— for the purpose of this standard practice*, TEDE is the sum of the dose to the body from external radiation plus the total eventual risk equivalent dose from intakes of radionuclides. Note that where the term "dose" is used in this document, it is understood to be used as a synonym of TEDE.

3.1.39 *transport index*—the dimensionless number (rounded up to the next tenth) placed on the label of a package to designate the degree of control to be exercised by the carrier during transportation. The transport index is determined by multiplying the maximum radiation level in millisieverts (mSv) per hour at 1 m (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour (mrem/h) at 1 m (3.3 ft)). **49 CFR 173.403**

3.1.40 *weapon of mass destruction (WMD)*—defined in U.S. law (18 USC §2332a) as a weapon meeting one or more of the following four categories: (*1*) any "destructive device" (such as explosives, incendiary material, or poison gas in a bomb, grenade, rocket, missile, or mine); (*2*) any weapon that is designed or intended to cause death or serious bodily injury through the release, dissemination, or impact of toxic or poisonous chemicals, or their precursors; (*3*) any weapon involving a biological agent, toxin, or vector; (*4*) any weapon that is designed to release radiation or radioactivity at a level dangerous to human life.

3.1.40.1 *Discussion*—WMD is often referred to by the collection of categories that make up the set of weapons: chemical, biological, radiological, nuclear, and explosive (CBRNE). These are weapons that have a relatively large-scale impact on people, property, or infrastruction, or combinations thereof. **CTOS 2014**

3.2 *Acronyms:*

3.2.1 *ABIS*—Arson Bombing Investigative Services

3.2.2 *AHJ*—Authority Having Jurisdiction

3.2.3 *ALARA*—As Low as Reasonably Achievable

3.2.4 *ANSI*—American National Standards Institute

3.2.5 *ATF*—Bureau of Alcohol, Tobacco and Firearms

3.2.6 *CBRN*—Chemical, Biological, Radiological, Nuclear

3.2.7 *CBRNE*—Chemical, Biological, Radiological, Nuclear, and Explosive

3.2.8 *CDC*—Centers for Disease Control and Prevention

3.2.9 *CEDE*—Committed Effective Dose Equivalent

3.2.10 *CFR*—Code of Federal Regulations

3.2.11 *CIA*—Criminal Investigative Analysis

3.2.12 *CIRG*—Critical Incident Response Group

3.2.13 *CRCPD*—Conference of Radiation Control Program Directors

3.2.14 *CTOS*—CTOS Center for Radiological/Nuclear Training at the Nevada National Security Site

3.2.15 *DCO*—Dosimetry Control Officer

3.2.16 *DHS*—Department of Homeland Security

3.2.17 *DOT*—Department of Transportation

3.2.18 *ECO*—Exposure Control Officer

3.2.19 *EOC*—Emergency Operations Center

3.2.20 *EPA*—Environmental Protection Agency

3.2.21 *ERG*—Emergency Response Guidebook

3.2.22 *FBI*—Federal Bureau of Investigation

3.2.23 *FEMA*—Federal Emergency Management Agency

3.2.24 *GM*—Geiger-Mueller

3.2.25 *IAEA*—International Atomic Energy Agency

3.2.26 *IC*—Incident Commander

3.2.27 *ICP*—Incident Command Post

3.2.28 *ICRP*—International Commission on Radiation Protection

3.2.29 *ICS*—Incident Command System

3.2.30 *IND*—Improvised Nuclear Device

3.2.31 *JTTF*—Joint Terrorism Task Force

3.2.32 *MACS*—Multiagency Coordination System

3.2.33 *MIPT*—Memorial Institute for the Prevention of Terrorism

3.2.34 *NCAVC*—National Center for Analysis of Violent Crime

3.2.35 *NCRP*—National Council on Radiation Protection and Measurements

3.2.36 *NFPA*—National Fire Protection Association

3.2.37 *NIMS*—National Incident Management System

3.2.38 *NIST*—National Institute of Standards and Technology

3.2.39 *NPP*—Nuclear Power Plant

3.2.40 *NRF*—National Response Framework

3.2.41 *OSHA*—Occupational Safety and Health Administration

3.2.42 *PAGs*—Protective Action Guidelines

3.2.43 *PPE*—Personal Protective Equipment

3.2.44 *PERD*—Personal Emergency Radiation Detector

3.2.45 *PRDs*—Personal Radiation Detector

3.2.46 *PRND/RND*—Preventive Radiological/Nuclear Detection or Radiological/Nuclear Detection

3.2.47 *R*—Roentgen

3.2.48 *R/h*—Roentgen per hour

3.2.49 *RDD*—Radiological Dispersal Device

3.2.50 *RED*—Radiation Exposure Device

3.2.51 *SI*—International System of Units

3.2.52 *SOIC*—Strategic Operation Information Center

3.2.53 *TDS*—Time, Distance, and Shielding

3.2.54 *TEDE*—Total Effective Dose Equivalent

3.2.55 *TI*—Transport Index

3.2.56 *TIS*—Terrorist Information System

3.2.57 *TKB*—Terrorism Knowledge Base

3.2.58 *TRACEM*—Thermal, Radiological, Asphyxiant, Chemical, Etiological, Mechanical

3.2.59 *TTIC*—Terrorist Threat Integration Center

3.2.60 *UN*—United Nations

3.2.61 *US*—United States

3.2.62 *WMD*—Weapon of Mass Destruction

4. Summary of Practices

4.1 This standard practice is based on existing resources and experience related to the development of radiological emergency response guidelines. This experience base is translated into a standard practice to guide responder agencies toward the goal of building operational guidelines for the emergency phase of radiological response. The standard practice is intended to enhance the ability, knowledge, and understanding of personnel, agencies, or departments that are responsible for responding to a radiological incident.

4.2 This standard practice shall be incorporated as a reference in Emergency Operation Centers (EOCs), emergency operation plans, and multiagency coordination systems (MACS) to assist in policy formulation and development of strategic objectives consistent with the objectives and needs of the Incident Commander (IC) throughout the incident. In incidents encompassing multiple agencies, multiple victims, and damage to environment and infrastructure the EOC and/or MACS would be operating at least at the local level. It is imperative that representatives at the EOC and/or MACS be aware of and understand the standard practice, and operate in concert with emergency response communities that adopt the standard practice .

5. Significance and Use

5.1 It is essential for response agency personnel to plan, develop, implement, and train on standardized guidelines that encompass policy, strategy, operations, and tactical decisions prior to responding to a radiological incident. Use of this standard practice is recommended for all levels of the response structure.

5.2 Documents developed from this standard practice should be referenced and revised as necessary and reviewed on a two-year cycle. The review should consider new and updated requirements and guidance, technologies, and other information or equipment that might have a significant impact on the management and outcome of radiological incidents.

6. Prerequisites for Radiological Emergency Response

6.1 AHJs over a radiological response are responsible for providing the planning, resources, training, and safety necessary to implement standardized procedures.

6.2 *Planning*—AHJs shall determine the specific requirements and planning elements for a response plan. The plan, and the documents that have significant impact on it or those that flow from it, shall be revised as necessary, in accordance with 5.2. The important elements of a plan include the following:

6.2.1 Type of response:

6.2.1.1 Radioactive materials are contained, the source is legitimate, and does not presently pose an exposure risk to human health or the environment or

6.2.1.2 Radioactive materials have been released or have the potential to be released or present an exposure hazard, or both, where radiation exposures or contamination, or both, are above typical background levels or implementation of protective action measures, or both, may be necessary.

6.2.2 Distinction between defensive and offensive operations:

6.2.2.1 Defensive operations plan will include (see Annex A1):

(1) Notification details.

(2) Definition of radiological hot zone: if the radiological hazard controls determination of the hot line, the maximum exposure rate for the hot line is recommended to be less than or equal to 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft); if radioactive material contamination is prevalent on scene, Annex A1 provides additional information regarding hot zone considerations (NFPA 472 3.3.15 Control Zones, NCRP Commentary No. 19; NCRP Report No. 165; CRCPD 2006; IAEA 2006; see Annex A1; see Appendix X1 and Appendix X2).

(3) For incidents where contamination has been identified, a scalable approach should be used for decontamination response (see Annex A1).

6.2.2.2 Offensive operations: In addition to the considerations summarized above for defensive operations a plan will include:

(1) Responder exposure rate decision points (Note: Exposures should always be minimized based upon ALARA (see Table X5.1) and are not considered absolute action levels but rather are incident management guidelines):

(a) The exposure rate, above which it is recommended operational personnel should be trained and protected by PPE, is less than or equal to 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft) (that is, the same value given to the hot line exposure rate if radiation exposure controls placement of the hot line location).

(b) The high exposure rate decision point is recommended not to exceed 100 R/h (1 Sv/h) when reasonably achievable; above 100 R/h (1 Sv/h) the IC shall only commit informed, consenting responders to short duration life-saving activities (see Annex A1; see Appendix X2 and Appendix X3).

(2) Recommendations for decision points and corresponding criteria for managing dose as follows (see Annex A1):

(a) NCRP does not recommend a dose limit for emergency responders performing time-sensitive, mission critical activities such as lifesaving. Instead, decision points should be established by the incident commander based upon operational awareness and mission priorities. This recommendation is consistent with existing national and international guidance reviewed which identifies the conditions and activities in which higher levels of dose may be warranted. In all cases, appropriate measures should always be taken to keep doses to individual emergency responders as low as reasonably achievable (the ALARA principle), given the situation and response objectives. This can be accomplished by minimizing the time spent in hazardous areas, wearing appropriate personal protective equipment (PPE), staff rotation, and establishing dose and dose-rate decision points.[22]

(b) There are a number of resources available that can be used to establish recommendations and criteria for managing emergency responder doses. The recently published *Planning Guidance for Protection and Recovery Following RDD and IND Incidents* (DHS, 2008) modifies previously issued guidance from the U.S. Environmental Protection Agency (EPA, 1992) by providing a description of justification for approaching or exceeding 50 rad (0.5 Gy) to a large portion of the body in a short time (an early exposure). Both NCRP (1993) and the Conference of Radiation Control Program Directors (CRCPD, 2006) recommend a 50 rad (0.5 Gy) decision dose to evaluate whether or not to remove personnel from continuing lifesaving operations. IAEA (2006) recommends 100 rem (1 Sv) personal dose equivalent (at 10 mm) for lifesaving efforts and ICRP (2005) places no cap on lifesaving. In all cases, emergency responders should be made fully aware of the risks of both early and late (cancer) health effects from such large doses. (NCRP 165)

(c) The following dose values are provided to help guide the incident commander when determining applicable decision points, considering the response situation using the ALARA principle:

(a) Less than or equal to 5 rem (0.05 Sv), all occupational activities.

(b) 10 rem (0.1 Sv), protecting valuable property necessary for public welfare.

(c) 25 rem (0.25 Sv), lifesaving or protection of large populations.

(d) 50 rem (0.5 Sv) decision point for lifesaving activities in catastrophic incidents.

6.3 *Resources*—The AHJ shall conduct equipment and resource needs assessments to determine the agency's requirements for radiation detection equipment, monitoring equipment, dosimetry, and specialized personal protective equipment (PPE). Instruments shall be calibrated and maintained in accordance with applicable and relevant society standards, including the recommended maintenance frequency.

6.3.1 The AHJ, based on the equipment and resource assessment, shall develop a response profile that details equipment requirements and the AHJ shall acquire the equipment that is necessary.

6.3.2 Minimum equipment prerequisites per team:

6.3.2.1 Contamination measuring instrument(s): the instrument, or combination of instruments, shall be able to detect alpha, beta, and gamma radiation, and shall have sensitivity equivalent to or greater than a pancake Geiger-Mueller (GM) instrument (see Annex A1).

6.3.2.2 Exposure rate instrument(s): an instrument or combination of instruments able to measure a range of exposure rate from 0.005 mR/h to 10 mR/h (0.05 uSv/h (microSv/h) to 0.1 mSv/h) for Preventive Radiological/Nuclear Detection (PRND) activities (such as search and interdiction of illicit material) and 0.1 mR/h to more than 100 R/h, possibly up to 1000 R/h (1 uSv/h to more than 1 Sv/h, possibly 10 Sv/h) for establishing the hot line and operating within the hot zone (see Annex A1).

6.3.2.3 Dosimetry devices: a dosimeter or personal emergency radiation detector (PERD) able to measure the highest level of penetrating radiation (gamma radiation and neutron

[22] NCRP 165 recommended decision dose approach.

radiation) team members are expected to receive; one dosimeter per team member is recommended, although it is recognized that resources may only allow one dosimeter per team; it is recommended that the dosimeter have a programmable alarming function (ANSI N42.49A and Annex A1).

6.3.2.4 PPE: select PPE based on hazard assessment.

6.4 *Training*—Personnel who have a responsibility for a radiological response shall have the level of training that will enable them to perform work tasks safely. The training shall include proper use of equipment and guidelines developed by the AHJ. Employees shall use hazard risk assessments to institute a safe working environment. The minimum level of training for responders shall be the current version of:

6.4.1 NIMS ICS,

6.4.2 Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120 (q) and General Duty Clause,

6.4.3 Any federal, state, local, or tribal regulatory requirements that apply, and

6.4.4 NFPA 472.

6.4.4.1 Chapter 5. Core Competencies.

6.4.4.2 Chapter 6. Mission Specific Competencies (for example, minimum PPE, monitoring, and detection).

6.5 *Safety*—Safety considerations by the AHJ are paramount to the success of the operation. The following safety issues will be considered in planning activities:

6.5.1 Ensure the proper equipment has been assembled and maintained for the mission.

6.5.2 Monitor strategic command operations and ensure use of self-protection concepts.

6.5.2.1 ALARA principles, which include time, distance, and shielding (see Annex A1, see Appendix X4).

6.5.2.2 Determine the feasibility of life safety operations based upon elapsed time, geographic distance from source, dose, exposure rate, stay times, and difficulty of life-saving operations (see Annex A1).

6.5.3 Develop site plans and document them as defined in 29 CFR 1910.120 (q) using dose reports, dose report with associated injury report, and personnel dosimeter logs (see Annex A1, see Appendix X5 and Appendix X6).

7. Radiological Emergency Response

7.1 The following sections establish a guide for safe radiological emergency response. They include the minimum requirements for analyzing, planning for, implementing, evaluating, and terminating the response.

7.2 *Analyze the Response*—The AHJ shall provide the emergency responder with the training and resources to recognize a radiological hazard, determine the scope of the problem, and predict the potential outcome of actions taken. Appendix X7 provides an example template for recording incident scene analysis.

7.2.1 Assess the scene and evaluate the possibility of a radiological hazard using the following on-scene indicators:

7.2.1.1 *Occupancies or Locations*—Responders shall be aware of establishments in their jurisdiction that may have radioactive materials present, in advance of a response (see Annex A1).

7.2.1.2 *Containers or Radioactive Material Packages*—Responders shall be able to identify the various types of radioactive material packages and the risks associated with the material typically found in each package type (see Annex A1).

7.2.1.3 *Natural Sources Including Building Materials*—Responders shall have the knowledge to recognize that naturally occurring sources may have an effect on radiological survey instrument readings. Responders shall identify building materials that have naturally occurring radioactive components and are likely to produce increased levels of background radiation (see Annex A1).

7.2.1.4 *Shipping Documents*—Responders shall use the information found on radioactive material shipping documents for risk assessment and response planning (see Annex A1).

7.2.1.5 *Signs and Symptoms*—Responders shall understand and recognize the signs, symptoms, and potential health effects of radiation exposure (see Annex A1).

7.2.1.6 *Intelligence Information*—Responders shall use information obtained from local, state or federal law enforcement and radiation authority agencies (see Annex A1).

7.2.1.7 *Monitoring and Detection Information*—Responders shall understand that initial indications of a radiological hazard will likely result from the use of their radiological instruments.

7.2.2 Efforts to determine accidental or intentional release shall be made from the onset of response. Exercise caution until such a time that the AHJ determines the release is accidental. This caution shall not hinder life safety response in any way, but shall increase situational awareness. Use the following information to determine if the release is accidental or intentional:

7.2.2.1 *Accidental*—Accidental releases of radioactive material can occur at a wide variety of locations including transit locations as a result of transportation accidents. The responder shall be able to assess the radiological emergency and determine whether it is accidental. Initial response actions prior to accidental or intentional release determination shall include investigating the potential for intentional release. Consultation with proper authorities, including radiation authorities, shall be a part of the assessment regarding accidental versus intentional release. Proper safety precautions and evidence preservation shall be considered. The following are examples of potentially accidental radiological hazards:

(1) Release at a facility such as a medical, research, construction, or industrial site (see Annex A1).

(2) Release in transport (see Annex A1).

(3) Breach in package (see Annex A1).

(4) Inappropriate packaging for the material (see Annex A1).

(5) Readings above a package Transport Index label (see Annex A1).

(6) Package containing radioactive material that is involved in a fire (see Annex A1).

(7) Orphan source (see Annex A1).

(8) Malfunctioning radiography source; this may occur at a site where radioactive materials are not normally found (see Annex A1).

7.2.2.2 *Intentional*—Intentional releases of radioactive material can occur anywhere as a result of a malicious or criminal act. A situation that appears to be an accidental release could indeed be an intentional act. Responders shall assess the radiological emergency to determine whether the cause appears suspicious. Additional concerns of an intentional release are hazards of a secondary device and crime scene/evidence preservation. Examples of intentional radiological releases include:

(1) Explosive Radiological dispersal devices (RDD) (see Annex A1).

(2) Radiation exposure devices (RED) (see Annex A1).

(3) Non-explosive RDDs and other deliberate acts of radioactive material release or radiation exposure (see Annex A1).

7.2.3 Determine the scope of the response:

7.2.3.1 Collect hazard information from various resources:

(1) Human sources (for example, witnesses, victims, subject matter experts (for example, radiation authorities), responsible party).

(2) Reference materials (for example, databases, written materials, modeling data).

7.2.3.2 Recognize and identify additional hazards (TRACEM).

7.2.3.3 Identify environmental conditions that have the potential to affect the response including geography, rural and urban environments, topography, and atmospheric/weather considerations.

7.2.3.4 Survey for radiation and contamination and monitor surroundings (see Annex A1; see Appendix X7).

7.2.4 Predict the potential outcomes: The IC interprets the information and predicts the likely outcomes of alternative response actions, including potential harm, through the use of scene analysis and situational awareness.

7.3 *Planning the Response:*

7.3.1 Based on analysis of the situation, develop an incident action plan (IAP) with available personnel and equipment, knowledge of the emergency response plan and the standard operating guidelines of the AHJ consistent with NIMS and ICS. It is important for this IAP to reflect ALARA principles (recognizing the potential immediate and long term health effects associated with radiation exposure – see Table A1.3 Medical Aspects of Radiation Injury). As part of a Risk Benefit Analysis, it is the responsibility of all response personnel to ensure actions are commensurate with potential benefits – managing all risks based upon ALARA and utilizing actionable decision points. Describe actions according to the following for both accidental and intentional incident (for intentional situation, additional considerations are presented in 7.3.4):

7.3.1.1 Self-protection concepts including ALARA principles: time, distance, shielding (see Annex A1).

7.3.1.2 Required resources (see 6.3):

(1) Equipment including contamination monitoring instrument, exposure rate instrument, and dosimeter.

(2) PPE.

7.3.1.3 Life safety operations: Rescue operations for life safety purposes shall be based on considerations incorporating the feasibility of responders to carry out missions, potential health effects, time required to complete rescue operations, and an evaluation of all hazards (TRACEM) on-scene. Specific decision points considered in a radiological event for life safety operations shall include the calculation of dose for both responders and victims. AHJs shall implement procedures for continuous evaluation of the need for and effectiveness of rescue operations (see Annex A1).

7.3.1.4 Emergency decontamination plan for contaminated victim(s): Decontamination operations shall include plans and provisions for prompt removal of contaminants from victims. Emergency decontamination plans shall incorporate processes to immediately reduce contamination of affected individuals in the absence of an established (formal) decontamination corridor (see Annex A1).

7.3.1.5 Technical decontamination plan: Decontamination operations shall include plans and provisions for implementation and operation of a formal decontamination corridor. PPE or specialized equipment will be utilized in the decontamination corridor by adequately trained response personnel. Plans shall incorporate specific processes for removal of contaminants. AHJs shall continually evaluate decontamination operations and be prepared to adjust for changes in hazard potentials and environmental conditions. Plans developed by AHJs should implement procedures allowing for immediate decontamination of victims and responders. If follow-up screening identifies further contamination on victims or responders, wet decontamination procedures may be necessary to reduce contamination to acceptable levels. When developing technical decontamination plans, AHJs shall include consideration of:

(1) Emergency responder(s) (see Annex A1).

(2) Contaminated victim(s) (see Annex A1).

(3) Equipment processing (see Annex A1).

(4) Evidence processing (see Annex A1).

7.3.2 Establish the following, and where appropriate define:

7.3.2.1 Type of radiological consideration:

(1) Radioactive material contained, the source is legitimate, and does not presently pose an exposure or contamination risk to humans or the environment, or

(2) Radioactive material has been released or has the potential to be released and it presents an exposure and/or contamination hazard situation and/or implementation of protective action measures may be necessary. If applicable:

(a) Differentiate between defensive and offensive operations.

(b) If possible determine whether incident is accidental or intentional; if intentional, monitor for secondary threats.

7.3.2.2 Decision points for defensive operations:

(1) Hot line: not to exceed 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft) above the ground and minimal contamination when reasonably achievable. It is important to recognize that the hot line is not to be determined precisely. For example, a boundary line approximating 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft) can be established for an instrument reading between 5 mR/h (0.05 mSv/h) and 20 mR/h (0.2 mSv/h) measured at waist height above the ground. These readings are essentially equivalent from the standpoint of health risk and operational flexibility. Where practical, the hot line zone should be established to match physical boundaries (such as streets and fences) that are close to the radiation levels identified above.

(2) It may not be practical to precisely survey map the entire perimeter of the hot line (hot zone outer boundary). The location of hot line can be established based on a limited number of survey locations be estimating the boundary line in areas where radiological surveys have not been performed yet. The hot line can be adjusted as new measurements become available.

(3) Locate incident command post (ICP), personnel, equipment, and decontamination operations in an area where there is no contamination and where it is unlikely to become contaminated during the response (for example, through wind-borne resuspension, etc.); if contamination is present, recommendations are provided in Annex A16.2.2.1*(2)*.

7.3.2.3 Decision points for offensive operations:

(1) Dose (see Annex A16.2.2.2*(2)*.):

(a) Less than or equal to 5 rem (0.05 Sv), all occupational activities.

(b) 10 rem (0.1 Sv), protecting valuable property necessary for public welfare.

(c) 25 rem (0.25 Sv), lifesaving or protection of large populations.

(d) 50 rem (0.5 Sv) for lifesaving activities in catastrophic incidents; the dose is recommended not to exceed 50 rem (0.5 Sv) when reasonably achievable.

(2) Hot line: not to exceed 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft) when reasonably achievable.

(3) Dangerous Radiation Zone: not to exceed 10 R/h (0.1 Sv/h) when reasonably achievable. Exposure and contamination levels within the dangerous radiation zone have the potential to cause early health effects if doses to people are not controlled and thus actions taken within this area should be restricted to time-sensitive, mission-critical activities such as lifesaving.

(4) High exposure rate: not to exceed 100 R/h (1 Sv/h) when reasonably achievable.

7.3.3 Describe actions to be taken based on the on-scene hazard analysis and AHJ's emergency response plans and procedures for the following:

7.3.3.1 Notification: appropriate notifications shall be made to emergency response and regulatory agencies in accordance with AHJ plans.

7.3.3.2 Request specialized resources and/or equipment (for example, subject matter experts, medical, law enforcement, fire service, and state/local/federal radiation, environmental, and health professionals).

7.3.3.3 Protective action considerations shall include: evacuation (EPA PAG Manual; DOT ERG, current version); shelter-in-place (EPA PAG Manual; DOT ERG, current version); scene control (DOT ERG, current version).

7.3.3.4 Documentation: shall be in accordance with statutory requirements (for example, local, state, federal, etc.) and AHJ's established plans.

7.3.4 Additional actions for initial response to an undetermined release and an intentional release are as follows:

7.3.4.1 Security provided by law enforcement including: security for a crime scene, secure area for command post, staging area, safe refuge area.

7.3.4.2 Awareness of secondary threat.

7.3.4.3 Preservation of evidence.

7.3.4.4 Investigation.

7.4 *Implementing the Planned Response:*

7.4.1 Implement the response to favorably change the outcome of a radiological incident consistent with emergency response plans and operating guidelines of the AHJ.

7.4.1.1 Given scenarios involving an accidental release of radioactive materials, the emergency responder shall describe the actions to be implemented based on 7.3.3 in the AHJ's response plans and operating guidelines.

7.4.1.2 Given scenarios involving an intentional release of radioactive materials, the emergency responder shall describe the actions they would implement in addition to 7.3.3 and 7.3.4 as noted in the AHJ's response plans and operating guidelines.

7.5 *Evaluating Progress:*

7.5.1 Evaluate and document the effect of actions implemented during a radiological incident, consistent with the response plan and the operating guidelines of the AHJ. If necessary, adjust the response plan to better achieve desired goals. The emergency responder shall evaluate the effectiveness of the actions taken in accomplishing response objectives in the following scenarios:

7.5.1.1 Actions taken in response to an accidental release of radioactive material, based on the actions identified in 7.3.3.

7.5.1.2 Actions taken in response to an intentional release of radioactive material, based on actions identified in 7.3.3 and 7.3.4.

7.6 *Terminating the Emergency Phase of the Response:*

7.6.1 During any radiological incident the emergency responder shall participate in the termination process including documentation of the incident, which is consistent with the emergency response plan and the operating guidelines of the AHJ. Orderly turnover of authority is key to terminating the emergency phase of the response. There will likely be a decontamination effort subsequent to the emergency phase.

ANNEX

(Mandatory Information)

A1. ADDITIONAL INFORMATION FOR RESPONDER USE

A1.1 The information provided below in the table is directly linked to the section numbers of this standard practice. The content linked to the section numbers provides the emergency responder additional details and examples related to the material content in the referenced section.

A1.2 After review of the standard practice and annex materials, Appendix X8 – Appendix X10 can be reviewed as additional tools for emergency responder communities. Appendix X8 contains guidelines for writing a radiological emergency response guidance document. It summarizes the recommendations of the standard practice in the form of guidance. Appendix X9 provides checklists that can be used by three audiences that will use this standard practice as follows: *(1)* the first on-scene responder that may not have specialized radiological training, *(2)* the operations level responder, and *(3)* individuals responsible for conducting radiation measurements. Appendix X10 provides a summary of radiation measurement units, conversions, and prefixes.

A1.3 Although radiation crisis communication is not expressly covered in the context of the standard practice, it is imperative for emergency responders to be able to communicate radiation risks. The U.S. EPA has produced a guide entitled "Communicating Radiation Risks" (EPA-402-F-07-008). It can be obtained directly from the EPA.

Section Number	Additional Information for Responder Use
1.4	The ERG (DOT, current edition) provides specific actions to be taken when radioactive materials are involved in transportation accidents. Responders using the ERG should be aware of the potential for secondary hazards that may exist and take precautions as necessary. In cases where the radiological hazard is not defined, jurisdictions should refer to the "Table of Placards and Initial Response Guide To Use On-Scene" section of the ERG for appropriate response actions.
6.2.2.1	For a total defensive operation, no one is expected to encounter a situation where they could die or compromise their health and safety. For defensive operations in the absence of victims, time is sufficient to develop a plan that reduces or negates radiation exposure. ALARA principles should always be a primary consideration in planning.
6.2.2.1*(2)*	*Hot Zone:* Appendix X1 provides two illustrations that represent zone considerations at a radiological incident. Appendix X2 is adapted from CRCPD 2006, IAEA 2006, and NCRP Commentary No. 19. It presents a summary of various exposure zones within the hot zone that responders could use for additional discrimination of zones to maximize protection of responder health. These additional considerations would be particularly beneficial during response to incidents that result in release of radioactive material such as that anticipated from an RDD terrorist event. Additional guidance for emergency responders managing an RDD event is available from Harper et al. (2007)[A] , Musolino and Harper (2006)[B] , and Musolino et al (2013).[I] *Contamination:* In addition to assessing the radiation levels present at a scene, responders should also be aware of the potential for radioactive contamination. Radioactive material that is properly contained, such as material in transport, as a component of certain devices, or as a sealed source, may pose only a radiation hazard. These sources do not pose a contamination hazard since the radioactive material is contained. The presence of contamination is usually an indication that radioactive material has been dispersed, such as in a RDD, or that the source/item containing the radioactive material has been breached. The responder should attempt to assess whether contamination is present, and act accordingly (for example, don appropriate PPE) if it is present to mitigate the spread of the material. If contamination is present responders may need to establish the hot line at a more conservative location than setting the hot line at less than or equal to 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft). This is especially important for those responders conducting operations without respiratory protection (for example, responders located at the ICP, or those manning the decontamination activities). The ICP should be established outside of an area of blowing dust, debris or settling ash. Table A1.1 presents contamination level recommendations with corresponding activity recommendations (CRCPD 2006; IAEA 2006; NCRP Commentary No. 19). Contamination levels can be measured using a variety of instruments such as a survey meter with a GM pancake probe or similar thin window GM detector. Since measurements will vary depending on the type of instrument used, it is important that responders become familiar with the background levels measured with their own instrument so they can determine if they are in an area with contamination levels above background. For RDD events, CRCPD 2006 recommends that, if possible, responders should set the ICP and the decontamination zone in areas with contamination levels of less than 1000 counts per minute (cpm) using a GM pancake probe, measured 1 to 2 in. from the ground.

Section Number	Additional Information for Responder Use

In an incident, such as a dirty bomb, containment and mitigation of the spread of radioactive material may be difficult if not impossible. Establish control zones as recommended by NFPA 472, NCRP Commentary No. 19, CRCPD 2006, and IAEA 2006. Table A1.1 summarizes guidance documents that provide contamination level recommendations.

Standard radiation survey instruments for detecting contamination read in cpm. As the cpm reading varies from probe to probe, depending upon the efficiency, the responder may need to convert cpm readings to disintegrations per minute (dpm) to accurately communicate radiological hazard information outside their organization. The conversion formula is:

dpm = cpm / instrument efficiency

Instrument efficiency is the percentage of the radioactivity present that a probe is likely to detect. For typical efficiencies, see CRCPD 2006.

In instances where it may be difficult to find an area with low levels of contamination (less than 1000 cpm), responders should follow the recommendations provided in NCRP Commentary No. 19 summarized in Table A1.1.

The units of dpm/cm^2 cannot be easily or practically converted during the chaos of actual events; therefore responders should become familiar with the efficiency of their instrumentation and make the appropriate conversions to cpm relative to their own instrument capabilities. It is suggested that responders calculate a specific conversion factor for each of their instruments in advance and record it with their equipment so it is readily available during a response (see the following note).

Note—How to convert from counts per minute (cpm) to disintegrations per minute per square centimeter (dpm/cm^2): A simple approach to convert between the units can be used, based on the efficiency of the instrument and the area of the probe. For example, if the probe area is 15 cm^2, which is a smaller area than the contaminated surface area being monitored, and the instrument has an efficiency of 20 % (that is, for every count per minute there are five disintegrations per minute), then converting the number of cpm to dpm/cm^2 can be calculated as follows:

Number of dpm/cm^2 = (Number of cpm measured /area of probe) * (Number of dpm/cpm)

In this example, given that the instrument has a 20 % efficiency, there are 5 dpm per each cpm, and since the area of the probe is 15 cm^2 :

Number of dpm/cm^2 = (cpm/15 cm^2) * (5 dpm/cpm) = dpm/(3 cm^2)

This means that responders need to divide the number of cpm they measure with their instrument by 3 to obtain the number of dpm/cm^2.

6.2.2.1*(3)* *Decontamination Plan:*

Decontamination is used to safely and effectively remove or lower contamination to an acceptable level from operational personnel and civilian victims. Protection of emergency responders, support personnel, and medical staff is the highest priority. The decontamination process also applies to the general public when it has been determined that decontamination is needed for potential or actual contamination. Emergency responders should be aware that the decontamination of equipment is also required. Care should be taken to recognize the potential for cross contamination and the need for evidence preservation, and appropriate safety precautions should be taken throughout the incident.

Emergency responders should be fully aware of the need to decontaminate victims (responders and civilians) arriving from areas with potential radioactive contamination. The AHJ and/or IC should establish a decontamination plan that outlines the policy and procedures for decontamination of ambulatory-injured and non-ambulatory injured victims. In the absence of other hazards (chemical, biological, explosives, etc.) all efforts should be made to adequately remove potential sources of radioactive contamination from victims. Injured victims from either group should be prioritized for treatment and transported as safely and expediently as possible (Smith et al., 2005[C]). Effective emergency decontamination for both ambulatory and non-ambulatory victims can be accomplished by removing the outer clothing and wrapping or re-dressing the victim in clean garments. Responders should consider the use of sheets, blankets, and disposable clothing (paper or cloth) allowing for continued medical treatment in designated cold zone areas once emergency decontamination is completed. Cases requiring "immediate need" or "life-saving" treatment should be addressed as soon as possible with respect to the emergency responder's safety. The plan should identify the delivery points for contaminated injuries.

For incidents where contamination has been identified, a scalable approach should be used for decontamination response according to the number of people contaminated. Consideration should be given to establishing in advance, as part of emergency response procedures, contamination action levels at which decontamination efforts would be initiated. Levels should be established in consultation with local, state, or federal radiation authorities. Guidance may be found in CDC 2007, NCRP 165, and IAEA 2006.

It is recommended that planners include consideration of any cultural or religious factors in the community that would affect decontamination of the general public (CDC 2007). It is not recommended that jewelry, personal effects, credit cards, etc. be taken from victims (CDC 2007). These items are important for resumption of normalcy by the general population.

The progression of a potentially contaminated victim should begin in the decontamination zone (removal of clothing) and move to the cold zone (wrapping and treatment). Emergency responders should be aware of the potential for cross-contamination to themselves and other response or receipt staff and the potential introduction of contaminants into the victim through open wounds and body openings. Once immediate medical treatment is rendered on-site, victims should be wrapped and/or clothed to allow for further evaluation and treatment. When possible, victims should be monitored to determine the level of contamination present. Emergency responders should record monitoring results on the patient's available records for first receiver use and review. Monitoring of victims receiving life-saving procedures should not be conducted if the effort will impede medical assessment and treatment (Smith et al., 2005[C]). Upon completion of treatment in the cold zone, and prior to rendering additional victim aid, emergency responders should follow standard protocols for self-decontamination prior to treatment of additional victims.

6.2.2.2*(1)(b)* *High Exposure Rate:*

Most resources that are available to provide guidance to emergency responders recommend an upper limit to the exposure rate that responders should manage during an emergency. For example, the CRCPD 2006 provides a recommendation that the high exposure rate should not exceed 200 R/h (2 Sv/h).

The responder will not advance from background to a high exposure rate limit instantly. Radiation levels will irregularly go up and down. Responders should continue monitoring dosimeters and track the time required to advance from position to position using a lower dose path when possible.

The responders and health physicists supporting the development of this standard practice recommend that since this standard practice does not include the IND scenario, responders and IC should have a decision point associated with the high exposure rate at a lower value; therefore 100 R/h (1 Sv/h) was selected. This recommendation does not preclude a responder and IC from making a decision to perform a very short duration operation in a higher radiation exposure field.

Appendix X3 provides a Stay Time Table as a tool for responders and IC to use to manage exposure rate and time to reach total dose. This table should be used with caution keeping in mind that radiation levels are not continuous and require careful monitoring.

Additional guidance for emergency responders managing an RDD event is available from Harper et al. (2007)[A] and Musolino and Harper (2006)[B] .

Section Number	Additional Information for Responder Use

6.2.2.2*(2)* *Dose:*

There are a number of resources available that can be used to establish recommendations towards emergency responder dose decision points and guidelines. The EPA's guidelines provide greater than 25 rem (0.25 Sv) for lifesaving activities or protection of large populations (EPA PAG Manual).[H] There is no upper limit provided by the EPA guidance. The FEMA RDD/IND Protective Action Guidelines (PAGs) (FEMA 2008) modify the EPA PAG Manual guidance slightly as described in Table A1.2. The International Commission on Radiological Protection (ICRP) (ICRP Publication 96), and the Conference of Radiation Control Program Directors (CRCPD 2006) all provide 50 rem (0.5 Sv) for life-saving. The International Atomic Energy Agency (IAEA 2006) provides a recommendation of 100 rem (1 Sv) for lifesaving.

The National Council on Radiation Protection and Measurement (NCRP) (NCRP Report No. 165)[F] does not recommend using the 5 rem, 10 rem, and 25 rem dose guidelines as absolute, maximum dose limits for emergency responders. For emergency responders preforming time-sensitive, mission critical activities such as lifesaving. Instead, decision points should be established by the incident commander based upon operational awareness and mission priorities. Provided that their doses are below the threshold for acute radiation syndrome, the Incident Commander (IC) might use 5, 25, and 50 rem (50, 250, and 500 mSv) or more as decision points (not limits) to control total dose. With resect to protecting property, the IC sometimes may decide to continue fire suppression even though radiation levels are high. A case in point might be a fire in a building that threatens an adjacent critical facility, such as an electric power substation, the destruction of which could entail large-scale societal disruption from the loss of electrical power.

Both the NCRP (NCRP Report No. 116; NCRP Report No. 165) and the Conference of Radiation Control Program Directors (CRCPD, 2006) recommend a 50 rem (0.4 Sv) decision dose (rather than a dose limit) to evaluate whether or not to remove personnel from continuing lifesaving operations. NCRP identified the decision dose of 50 rem (0.4 Sv) with the assumption that additional dose would be accumulated as the emergency responder withdrew from the area (NCRP Commentary 19. If warranted by the mission and circumstances, continuing the mission could be a legitimate decision even after an emergency worker receives the 50 rem (0.5 Sv) decision dose. The 50 rem (0.5 Sv) decision dose was developed in an effort to keep an emergency responder's individual dose from unintentionally surpassing 100 rad (1 Gy), below which clinically-significant early health effects are not likely to occur. Early health effects are not likely unless individuals receive doses exceeding 150 to 200 rem (1.5 to 2 Sv) to a substantial portion of the body.

In all cases, emergency responders should be made fully aware of the risks of both early and late (cancer health effects from such large doses. NCRP (NCRP Report No. 165) recommends that, to the extent practical, informed consent of such emergency workers be obtained in advance of a radiological or nuclear terrorism incident and not when such an incident occurs.

Table A1.2 summarizes the EPA PAGs (EPA 2013).

6.3.2.1 *Contamination Measuring Instrument(s):*

An instrument or combination shall be able to measure alpha, beta and gamma radiation. The instrument(s) should have a minimum 2-pi detection efficiency of:

10.0 % for alpha radiation, based on a plutonium-239 source

5.0 % for beta radiation, based on a carbon-14 source and,

15 % for radiation from a Cs-137 source (beta plus gamma)

6.3.2.2 *Exposure Rate Instrument(s):*

Each instrument should be able to measure, at a minimum, exposure rates from photon radiation with energies between 60 keV and 1.33 MeV. This specified range covers Am-241 at the low end of the energy range, to Co-60 at the high end.

Each instrument should be accurate to within ±30 % across the specified range of detection (ANSI N42.33), and should be equipped with a visual and audio indication of exposure rate.

ASNI Standard N42.33 (ANSI N42.33-2006a), "Portable Radiation Detection Instrumentation for Homeland Security" recommends that detection instruments for Preventive Radiological/Nuclear Detection (PRND) activities have an operating range from 0.005 mR/h (0.05 uSv/h (microSv/h)) to at least 10 mR/h (0.1 mSv/h). This range of exposure rates is primarily good for search and interdiction activities. Once the presence of radiation is confirmed, equipment that measures exposure rate at higher levels might be more advantageous. Most models of PRDs will overload and cannot operate in high exposure rates. Some models of PRDs can also perform the safety functions of a personal emergency radiation detector (PERD) and monitor the radiation dose rate and dose in high exposure rates.[E]

The following National Institute of Standards (NIST) documents can help organizations appropriately choose instruments for the environment in which they plan to use them:

"Results of Test and Evaluation of Commercially Available Survey Meters for the Department of Homeland Security," NIST, 2005 and "Round 2", NIST, 2006 (NIST 2006a; NIST 2005a)

Distribution of these documents is authorized to federal, state, local, and tribal responders. Other requests for this document should be referred to the Department of Homeland Security, Science and Technology Directorate, Standards Executive.

The recommendation for a high exposure rate of 100 R/h (1 Sv/H) makes it necessary to have access to instrumentation that can monitor to at least 100 R/h. An instrument or combination of instruments should be able to measure from 2 mR/h (0.02 mSv/h) to at least 100 R/h (1 Sv/h) or higher.

6.3.2.3 *Dosimetry Devices:*

An instrument should be able to measure photon exposure between 60 keV and 1.33 MeV to within 20 % of the true value. The instrument should be able to record and retain accumulated dose information for 90 days with less than 5 % variation from the initial value.

See NCRP Commentary No. 19 for guidance on alarm point settings for electronic dosimeters. Alarming dosimeters should have preset alarms at decision points for exposure rate and dose established in planning and training (for example, 10 mR/h (0.1 mSv/h), 50 R/h (0.5 Sv/h) (one-half of the 100 R/h (1 Sv/h) high exposure rate, etc.).

See ANSI standard N42.32 (ANSI N42.32) for performance criteria related to alarming personal radiation detectors (PRDs). This standard entitled, "Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security" describes design and performance criteria for instruments that are pocket-sized and worn on the body for the purpose of rapid detection of radioactive materials. The range of measurements covered by the standard is limited to the range of 0.005 mR/h (0.05 uSv/h (microSv/h)) to not less than 2 mR/h (0.02 mSv/h). See the following National Institute of Standards (NIST) documents, which can help organizations appropriately choose instruments for the environment in which they plan to use them:

"Results of Test and Evaluation of Commercially Available Personal Alarming Radiation Detectors and Pager for the Department of Homeland Security," NIST, 2005 and "Round 2", NIST, 2006 (NIST 2006b; NIST 2005b).

Distribution of these documents is authorized to federal, state, local, and tribal responders. Other requests for this document should be referred to the Department of Homeland Security, Science and Technology Directorate, Standards Executive.

Dosimetry for operations in the hot zone should extend at least to the high exposure rate. Quartz fiber detectors or colorimetric detectors are dosimetry options for response communities. A team with a contamination survey meter and a dose rate meter may find it sufficient to equip each team member with this equipment to serve as personal radiation dosimetry.

Alarming personal emergency radiation detectors (PERDs) are used to manage exposure by alerting the emergency responders when they are exposed to gamma radiation. The instrument provides rapid and clear indication of the level of radiation exposure (dose) or exposure rate (dose rate), or both, and readily recognizable alarms. The alarms are both audible and visual, and distinguishable between exposure rate and exposure. The accuracy requirements for PERDs are not as stringent as the requirements for alarming dosimeters, but PERDs are designed to be operated in high exposure rates by emergency responders wearing PPE. Although a PERD may physically resemble a Personal Radiation Detector (PRD), the key difference is that the PRD's primary function is detection and the PERD's primary function is safety monitoring. The PRD detects and alarms on small increases in gamma radiation levels (dose rate), while the PERD can measure and alarm on very high levels of radiation in which most models of PRDs would be overloaded and inoperable. Some models of PRDs can also perform functions of a PERD in high levels of radiation.[E, G]

Section Number	Additional Information for Responder Use
6.5.2.1	*Time, Distance, and Shielding (TDS):* TDS is an effective way for responders and dosimetry coordinators, exposure control personnel, or safety officers to implement dose reducing practices in radiological incidents. TDS does not require new or additional equipment to reduce potential exposures. In short, it can be defined as follows: Time: Responders should strive to spend the least amount of time possible in a hazardous environment (chemical, radiological, biological, etc.), while performing the mission or task assigned. Minimizing time in or around a source of radiation will minimize the dose to the responder, and effectively reduce the overall dose received during an incident. AHJs should consider the use of staff rotations to minimize responder dose. Rotation of staff to perform lengthy missions will allow individual responder doses to be reduced allowing for lower doses to a larger segment of the responders at the incident. Responders should consider the use of time as a key self-protective measure during radiological response. Distance: Responders should approach all incidents from a distance that provides adequate protection, while allowing for scene size-up, evaluation of mission requirements, and the eventual mission execution. Distance plays a key factor in reducing radiological exposures. The Inverse Square Law is one means to calculate probable exposure rates from unshielded point sources of gamma radiation. Simply stated, each time a responder doubles the distance between their person and a source of gamma radiation, the exposure rate will be reduced by a factor of four. Inversely, each time the responder reduces the distance by one-half (gets closer to the source), the exposure rate will increase by a factor of four. For the responder, it is important to note that using distance as a self-protective measure can significantly reduce unnecessary dose. Shielding: Responders should recognize shielding as a viable means to reduce dose. Although specialized shielding will not normally be available during initial response to an incident, shielding can play a key role in dose reduction. Responders should approach an incident using shielding from buildings, vehicles, earth barriers, and other potential sources. In incidents involving transportation packaging and radiation devices, responders can approach from the "shielded" side of a source of radiation and perform missions with a significantly reduced dose potential. Responders should use existing sources of shielding to reduce dose. Anything placed between a responder and a source of radiation will reduce overall dose. Because of the large amount of materials required to shield gamma and neutron radiation, it is often not practical to try to wear extra shielding or build shielding walls around a radiation source. Do not delay rescue operations to search for or build shielding. Responders should be trained to recognize the benefits of TDS. TDS concepts are summarized in Appendix X4.
6.5.2.2	*Life Safety Operations:* The feasibility of life safety operations should be determined through use of protocols and decision points established by the AHJ. Considerations include, but are not limited to, the short and long-term health effects to the responder from the operations, health effects of the event on victims, and capability of the AHJ to carry out life-saving missions. Specific decision points considered in a radiological event for life safety operations, when determining the feasibility of operations, should include the calculation of dose to the responder and the corresponding dose received by the victim. AHJ's should develop and implement procedures that provide for the continuous evaluation of responder doses against the effectiveness of offensive actions. Evaluation of the feasibility for life-saving operations can be categorized by the AHJ using the following: Elapsed time: the time from notification of event or awareness of a radiological threat, to the time life safety operations begin. Geographic distance from source: the physical distance a victim is from a source of ionizing radiation, coupled with the physical distance a responder should travel to safely and effectively perform life-saving treatment or rescue. Exposure rate: the amount of exposure the responder and victim are expected/estimated to receive from the source of radiation, given elapsed time and the geographic distance considerations; exposure rates should be verified and routinely evaluated for changes in conditions that may decrease or increase the dose to responder and victim. Stay times: see 6.5.2.1 and Appendix X3. Difficulty of life-saving operations: determination by the AHJ on type (simple or technical) of rescue necessary; time required for safe and effective rescue operations; number of victims requiring rescue; condition/status of victims; availability of resources to carry out rescue operations (trained personnel, equipment, and commodities); geographic distance required for victim assessment, transport, and safe treatment; and the scope (size) of the area impacted by the event.
6.5.3	Emergency responders should consult with local or state radiation control program personnel for forms that will be consistent with radiation control specific considerations. An example document that folds in dose report and personnel dosimetry logs is provided in Appendix X5. In considering dose reports with injuries AHJ's should report injuries occurring at the incident site in compliance with established local, state, and federal requirements. Injury reports should be developed in accordance with established policies developed and determined by the jurisdiction. In a radiological incident, jurisdictions should ensure that radiological dose information be included in an injury reporting mechanism. Dose information can be gathered through the following: radiation dose record instruction cards that can be provided to each responder; see Appendix X6 for an example dose record log alarming and direct read dosimetry records available through the ICS pertaining to mission assignment, accountability, and safety Under no circumstances should the inclusion of dose records prevent immediate treatment and transport of responders or civilians injured at incident sites. Dose records should be forwarded to medical professionals as soon as possible for consideration in potential treatment options at the first receiver location. Dose records may be transmitted verbally at the onset of treatment, but should be summarized in writing and provided to the first receiver. AHJ's should train response personnel that radiological exposures may not result in immediate effects. Signs and symptoms of exposure may be the result of other influences including stress, exhaustion, chemicals, etc.

Section Number	Additional Information for Responder Use
7.2.1.1	*Occupancies or Locations:* When responders arrive at any type of incident and are conducting the scene analysis, they should look for unusual or out-of-place incident scene indicators. Size and shape of smoke plumes, odors, large debris fields, and craters from explosions are a few examples of things to look for. If a terrorist event is suspected, responders should have a heightened sense of situational awareness. They should proceed cautiously, evaluating the scene for radiation levels and areas where secondary devices might be placed. They should visually scan operating areas for secondary devices and avoid touching or moving anything that could conceal an explosive device. Building occupancies fall into several categories. Each occupancy type and location presents potential hazards to emergency responders. The potential for an incident involving radioactive material is possible at any type of occupancy listed in Table A1.4. Some of the facilities listed have or use radioactive material as part of their everyday operations and others could be attacked using radioactive material as a hazard to the occupants. It would not be uncommon for responders to encounter radioactive sources at industrial, construction, mercantile, or medical facilities. It would be unlikely that responders would encounter radioactive sources at assembly, educational, correction, or storage facilities. Planning for occupancies is the best method for identifying potential radioactive sources within the various types of occupancies. Several simple steps could include the documentation of background readings and sources in the plan at all types of occupancies. It should be noted that the minimum requirement of a response agency as noted here do not supersede the requirement of NUREG-0654 that prepare responders in close proximity to nuclear power plants (NPPs) (NUREG-0654/FEMA-REP-1; NUREG-0654/FEMA-REP-1, Rev. 1 Addenda). Response agencies surrounding NPPs will have advanced protocols and training programs and will likely find this standard elementary compared to their state of readiness.
7.2.1.2	*Containers or Radioactive Material Packages:* Federal regulations place strict administrative controls on the transport of radioactive material. The worldwide philosophy of radioactive material transport is that safety should be primarily focused on the package. Regulations require that packages be marked and labeled so responders can easily recognize the package type, identify the radioactive material content and activity of the material inside the package. Package durability is directly related to the degree of hazard of the material inside the package. This two-part philosophy means that non-life endangering amounts of radioactive material can be shipped in packaging designed to withstand normal transport conditions. Packages that contain life endangering amounts of radioactive material will be shipped in packages designed to withstand severe accident conditions. The five package categories used to transport radioactive material are: Excepted packages: Excepted packaging is used to transport material with extremely low levels of radioactivity. It is authorized for limited quantities of radioactive material that would pose a very low hazard if released in an accident. Industrial packages: Industrial packages are used to transport slightly radioactive materials. Transporters use such containers for most low-level radioactive waste. Type A packages: Type A packages are used to transport materials that are more radioactive than material shipped in excepted and industrial packages. Type A packages are designed to protect their radioactive contents under a variety of normal transportation conditions. These packages must meet stringent testing requirements, including water spray, drop, compression, penetration, and vibration tests. Type B packages: Type B packages are used to transport materials with the highest levels of radioactivity, such as used nuclear fuel. They are designed with the assumption that accidents happen. These packages provide radioactive protection and nuclear safety under very severe accident conditions. These packages are designed to survive simulated accident conditions, such as water immersion, a 30-foot drop onto an unyielding surface, severe penetration and extreme heat, and also should prevent a nuclear reaction during normal and accident conditions. Type C packages: Type C packages are used for high-activity materials (for example, plutonium) transported by aircraft. They are designed to withstand severe accident conditions associated with air transport without loss of containment or significant increase in external radiation levels. The Type C package performance requirements are significantly more stringent than those for Type B packages. Type C packages are not authorized for domestic use, but are authorized for international shipments of radioactive material.
7.2.1.3	*Natural Sources Including Building Materials:* Some building materials have inherent radioactive constituents. Building construction types that use large quantities of concrete, granite, or ceramic tile may have increased levels of background radiation. For example, the granite blocks at street-level outside the Thomas Jefferson Building at the Library of Congress and the red marble pedestal for the statue of Roger Williams in the Capitol building produce 30 microR/h (0.3 microSv/h). Wood or steel frame type constructions are less likely to have increased levels of background radiation. Responders should have an understanding of building types and construction materials to increase their ability to recognize or identify radioactive materials at an event scene.
7.2.1.4	*Shipping Documents:* Limited quantities of radioactive material may be shipped in excepted or industrial packaging without shipping papers. Each Type A, B, C, Low Specific Activity, or Surface Contaminated Object shipment of radioactive material is required to be accompanied with paperwork that documents the shipment. The paperwork requirements are outlined in the US DOT CFR (49 CFR 173.403). There are numerous items that are required to appear on the shipping papers. Some of these items include: proper shipping name, emergency telephone number, chemical and physical form of the material, the shipper and receiver's contact information.

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7.2.1.5 *Signs and Symptoms:*

Determining whether a person has been exposed to radiation based on signs and symptoms may not be as easy as it is for chemical and biological threat agents. It takes a very large dose of radiation to produce immediate (acute) effects. Persons who receive a large dose of radiation in a short period of time may suffer the effects of what is called Acute Radiation Sickness (ARS). ARS is an acute illness caused by a large dose of penetrating radiation (gamma or neutron) delivered to most or all of the body in a short period of time, usually within a matter of minutes. ARS is also commonly referred to as radiation sickness or radiation toxicity. Notable examples of persons who have suffered from ARS are the survivors of the atomic bombs that were dropped at Hiroshima and Nagasaki as well as the firefighters who received large acute doses of radiation during the initial phase of the Chernobyl NPP accident.

For the range of incidents covered by this standard it is not anticipated that ARS symptoms will be observable; however ARS information is provided in order to provide background in the event victims presents symptoms that might be related to an incident such as placement of a large RED. It's also possible that a would be terrorist handling radioactive materials improperly presents ARS symptoms that could help law enforcement to prevent an incident.

Signs and symptoms of ARS can occur within minutes to several hours after the exposure. The symptoms are nonspecific and consist of nausea, vomiting, diarrhea, anorexia and malaise. Depending on the magnitude of the exposure, the symptoms range from mild nausea to violent vomiting with hematemesis (blood in the vomit) and bloody diarrhea with circulatory collapse. In general, the higher the dose, the greater the magnitude of symptoms and the more rapid their onset. Many people exposed to large acute doses of radiation will remain asymptomatic during the first several hours following exposure; therefore, the absence of symptoms during this phase does not mean that a person has not been exposed. A patient with ARS symptoms shortly after exposure will, however, have received a large, probably fatal dose of radiation, and this should be kept in mind during triage. The early symptoms are non-specific (nausea, vomiting, etc.) and can easily be attributed to other causes such as a head injury, abdominal injury, or even fright. Conversely, these causes can be mistakenly attributed to ARS, and treatment for a life-threatening injury can be delayed. For this reason, it is important for emergency response personnel to keep ARS in mind if other on-scene indicators warrant, but also not to over diagnose it.

Terrorists transporting, storing, or assembling a device may have radiation burns, especially on the hands, without getting ARS. The U.S. Department of Health and Human Service's Radiation Emergency Medical Management (REMM) website is a good source for more information on signs and symptoms (http://remm.nlm.gov).

7.2.1.6 *Intelligence Information:*

Intelligence is the first level of protection against domestic terrorism. Response agencies may be activated based on intelligence gathering by local, state or federal law enforcement agencies to confirm or deny suspicions (for example, check for the presence of radioactive materials), or implement protective actions if sources are considered reliable or probable. Interviewing and interrogation, along with records checks, are the most commonly used techniques for intelligence gathering, followed by use of informants. In addition, case records, items recovered during searches, statements from testimonies, court and business records, electronic surveillance, open source (for example, internet) information, and undercover infiltration are some other typical sources of domestic intelligence data that may prompt law enforcement action.

The Federal Bureau of Investigation (FBI) is the lead agency for the investigation of domestic terrorism. If explosive devices are suspected to be involved, the Bureau of Alcohol, Tobacco and Firearms (ATF) will be involved, and there may be other instances of information sharing at state and local levels. Joint Terrorism Task Forces (JTTFs) are set up throughout the U.S. in strategic geographical areas, and several support units also exist at Quantico and elsewhere (for example, Critical Incident Response Group (CIRG), National Center for Analysis of Violent Crime (NCAVC), Arson Bombing Investigative Services (ABIS), and Criminal Investigative Analysis (CIA) program). In addition, the FBI has long maintained an on-line computer database known as the Terrorist Information System (TIS) which contains information on suspected terrorist groups and individuals. Currently, the best domestic terrorism database is the Memorial Institute for the Prevention of Terrorism (MIPT) Terrorism Knowledge Base (TKB). Other capabilities exist within the FBI, such as the Terrorist Threat Integration Center (TTIC), and the multi-crisis Strategic Operation Information Center (SOIC). Radiation authorities can also provide subject matter expertise towards developing intelligence information.

7.2.2.1*(1)* *Release at a Facility Such as a Medical, Research, Construction, or Industrial Site:*

Individual locations within facilities where radioactive materials are used and stored are typically identified with signs and postings. Signage includes the words "Caution–Radioactive Material" or "Caution–Radiation Area" along with the tri-foil symbol. Radioactive material used at construction sites is typically packaged for transport. Package markings may include United Nations (UN) identification number, proper shipping name, and radioactive labels.

Releases can occur during routine use of materials through carelessness, failure of workers to properly survey areas following use, and other events, such as fire or flood, that cause materials to be released. Accidental releases at construction sites are often the result of heavy construction equipment rolling over and crushing the device that contains the radioactive source.

7.2.2.1*(2)* *Release in Transport:*

Radioactive materials may be found in all modes of transportation. Highway, air, and rail are the most common. Releases during transport may result when packages are damaged or breached during accident situations. Placarding and UN identification numbers may be present on vehicles and railcars transporting radioactive material. It is based on shipment quantities and radiation levels. Not all shipments of radioactive material require placarding. It is important to note that radioactive material package integrity is directly related to the hazard of the material contained inside the package. This means that releases would not be expected in cases where life-endangering amounts of radioactive material are being transported because the package is built to withstand severe accident conditions.

7.2.2.1*(3)* *Breach in Package:*

It is normal to find measurable radiation levels on the exterior of intact packages. Labeling requirements are based, in part, on the radiation levels present on the surface and at 1 m from the surface of undamaged packages. Radiation levels from breached packages may not match the levels indicated by the category of label attached to the package, and could be significantly higher than indicated by the attached label. Breached packages also have an increased risk and likelihood of radioactive contamination. It is good practice to collect wipe samples from breached packages to assess for potential contamination.

7.2.2.1*(4)* *Inappropriate Packaging for the Material:*

The packaging of radioactive material for shipments is intended to remain intact so that radiation levels outside of the package do not change during transport. Radiation levels may be lower due to natural radioactive decay. On occasion, material may be packaged or labeled inappropriately. Contents of the package may not match shipping papers or affixed labels. Inappropriate packaging may allow contents to shift during transport resulting in discrepancies between radiation levels indicated on labels and shipping papers and those measured in the field.

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7.2.2.1*(5)*	*Readings Above Transport Index:* The transport index (TI) is used to control the number of packages on a conveyance during transport. The TI is shown on Radioactive Yellow-II and Yellow-III labels and on the shipping papers. The shipper determines the TI prior to shipment by taking the radiation level (in mrem/h) at a distance of 1 m from the package. Responders can use the TI as an indicator of package integrity by comparing the radiation level at 1 m from the package with what is listed on the package label or shipping papers. Due to differences in calibrations between responders' and shippers' instruments, and in errors associated with estimating an exact 1 m distance in the field, the package may still be intact even if the responder reading is recording higher or lower levels than the listed TI.
7.2.2.1*(6)*	*Package Containing Radioactive Material That is Involved in a Fire:* Packages and packing material used in radioactive material shipments may be cardboard, fiberboard, wood, plastic, or other combustible material. Fire does not change the radioactive properties of the material being shipped, although it may change the chemical or physical properties of the radioactive materials allowing it to be liberated more easily. Radiation levels may increase as a result of package degradation or destruction resulting from involvement in a fire. Contamination levels may increase significantly. Radioactive material may be present in the smoke plume creating an inhalation hazard. Radioactive material may also be found in water runoff or other extinguishing media used for fire suppression. The packages used to contain the highest levels of radioactivity (Type B Packages) are designed to withstand severe accident conditions including total engulfment in a fire without releasing their contents
7.2.2.1*(7)*	*Orphan Source:* The term "orphan source" refers to a radioactive source that is not under regulatory control, either because it has never been under regulatory control, or because it has been abandoned, lost, misplaced, stolen, or transferred without proper authorization. The term does not apply to contaminated soils and bulk metals. The following conditions generally apply to orphan sources: Uncontrolled condition that requires removal to protect public health and safety from a radiological threat. Controlled or uncontrolled, but for which a responsible party cannot be readily identified. Controlled, but the material's continued security cannot be assured; if held by a licensee, the licensee has few or no options, or is incapable of providing for, the safe disposition of the material. In the possession of a person, not licensed to possess the material, who did not seek to possess the material. In the possession of a state radiological protection program for the sole purpose of mitigating a radiological threat because the orphan source is in one of the conditions described in one of the first four bullets and for which the state does not have a means to provide for the material's appropriate disposition. Orphan sources may be the result of theft by parties who are unaware the material is radioactive and who later abandon the material or device. Packages may still have markings or labels to identify contents and radiation levels. Orphan sources may also be identified by radiation monitors at waste processing facilities, landfills, or metal recyclers.
7.2.2.1*(8)*	*Malfunctioning Radiography Source:* Gamma radiography cameras are used in non-destructive testing of welds of beams, gas and oil pipes, etc. In these cameras, the radioactive source is housed in a shielded device and is moved through a guide tube to a collimator inside the pipe. Controlled beams of radiation are emitted from the source (usually Iridium 192) through the weld and onto the photographic film. The resulting radiograph will show any flaws in the weld. Industrial accidents with radiography sources can occur due to disconnection of the source from the drive cable resulting in not being able to return the source to the shielded container or the operator may not be able to retract the source into the shielding.
7.2.2.2*(1)*	*Explosive Radiological Dispersal Devices (RDDs):* A Radiological Dispersal Device (RDD) is any device that intentionally spreads radioactive material across an area with the intent to cause harm, without a nuclear explosion occurring. An RDD that uses explosives for spreading or dispersing radioactive material is called an "explosive RDD."[E] Depending on wind speed and direction, the radioactive material could be spread over a large area. Because fires, which would likely occur following an explosive RDD incident, could further spread radioactive material responders should extinguish fires as soon as it is safe to do so. If there is any indication that an explosion has occurred, responders should take precautions in case radioactive materials were involved. Look for unusual or out-of-place incident scene indicators, including vehicle fires, smoke plumes, odors, large debris fields, or craters. Elevated radiation exposure rate or contamination readings at multiple locations would be another potential indicator that an RDD has been used. If you suspect a terrorist event, proceed cautiously, evaluating the scene for radiation levels, areas where secondary devices might be placed, and locations where other hazards may exist. Visually scan operating areas for secondary devices before providing patient care. Avoid touching or moving anything that could conceal an explosive device. Use care to preserve evidence. Do not move fatalities, and try not to disturb anything you think might be useful to law enforcement when the crime scene is investigated. Evaluate the geographic and environmental factors that can complicate a radiological terrorism incident, including prevailing winds that will carry airborne radioactive particles, broken water mains, vehicle and/or pedestrian traffic flow, ventilation systems, or other natural or man-made influences, including air and rail corridors. Designate and enforce scene control zones. Once scene entry is made, evacuate victims and non-essential personnel who did not follow verbal instructions to leave the area as quickly and safely as possible.
7.2.2.2*(2)*	*Radiation Exposure Devices (RED):* An RED is a device intended to cause harm by exposing people to radiation without spreading radioactive material. An example of a RED is unshielded or partially shielded radioactive material placed in any type of container and in a location capable of causing a radiation exposure to one or more individuals. Also called a "Radiological Exposure Device (RED)."[E] An RED may cause a few deaths, but normally would not cause widespread radiological contamination. An RED may be hidden in public transportation (under a bus or subway seat), a busy shopping mall (the food court, for example) movie theater, or any other location where a large number of people may sit, stand, or pass close by. REDs reputedly have been used to target specific individuals by being placed in the individual's vehicle, office, or home. The danger is from exposure, for extended periods of time, to high levels of radiation close to the radioactive material. Individuals who come in contact with, touch, or sit on a radioactive material container do not become contaminated. However, if an RED were to break open, then some of the radioactive material could be released, causing contamination. If this occurs, the RED becomes a non-explosive Radiological Dispersal Device (RDD), and people coming in contact with it could spread contamination elsewhere.[E] Visual indicators for a RED are unlikely. Emergency responders would most likely be dispatched because of personnel in a specific area exhibiting symptoms of radiation sickness, or because someone with radiation detection equipment discovered radiation in an unexpected place. If REDs are suspected, responders should evacuate the area, establish corridors, and carefully plan scene entry, using principles of time, distance, and shielding to minimize exposure. Lead containers will be required to store highly radioactive sources. If safe to do so, it would be prudent to wait until radiation authorities arrive to assist with planning for retrieval and disposal of the devices.

Section Number	Additional Information for Responder Use
7.2.2.2*(3)*	*Non-explosive RDDs and Other Deliberate Acts of Radioactive Material Release or Radiation Exposure:* Non-explosive RDDs could spread radioactive material using common items such as pressurized containers, fans, building air-handling systems, sprayers, crop dusters, or even spreading by hand.[E] The deliberate contamination of food, water, or other consumables with radioactive material is another possibility for an attack. This could range from contamination far from the point of consumption that could potentially affect a large number of people, but with only very small quantity of radioactive material being consumed by any individual, or contamination close to the point of consumption, which would likely affect fewer people, but with a larger quantity of radioactive material being consumed by each individual.[F] It might also include random placement of contaminants in public locations so that they can be spread widely. Visual indicators for radioactive material distribution are unlikely. Emergency responders would most likely be dispatched because of discovery of a suspicious device, or because someone with radiation detection equipment discovered radioactive contamination in an unexpected place. Symptoms of radiation sickness would not be expected soon after the weapon was used because symptoms from internal contamination may not manifest for long periods of time, if ever, depending upon how much material is ingested. Terrorists could cause the dispersal of radioactive material from fixed radiological or nuclear facilities or materials in transit. For localities with fixed radiological or nuclear facilities that already have emergency response plans in place for accident scenarios and unplanned releases of radioactive material, the emergency response to an attack or sabotage of such facilities is similar to the response necessary for an RDD. The general response plan to transportation accidents involving any radioactive material would be adequate for the initial response to sabotage of any quantity of radioactive material in routine transport. All such plans should consider that such incidents could be a terrorism incident or an accident.[F]
7.2.3.4	*Survey for Radiation and Contamination and Monitor Surroundings:* An initial site survey should be conducted to document the extent of radiation, relevant radiation readings, landmarks, and distances. Appendix X7 presents an example radiological assessment site survey form for documenting relevant information at a fixed facility.
7.3.1.1	*Self-Protection Concepts Including ALARA Principles:* Self-protection ALARA concepts of TDS can be reviewed in annex section 6.5.2.1. Recall that responders should strive to spend the least amount of time possible in a hazardous environment (chemical, radiological, biological, etc.), while performing the mission or task assigned. Responders should approach all incidents from a distance that provides adequate protection, while allowing for scene analysis, evaluation of mission requirements, and the eventual mission execution. Responders should recognize shielding as a viable means to reduce dose. Time, distance, and shielding can all be employed by responders to reduce dose and ensure safe and effective missions. TDS concepts are summarized in Appendix X4.
7.3.1.3	*Life Safety Operations:* Life safety operations have been previously discussed in annex section 6.5.2.2. The feasibility of life safety operations should be determined through use of protocols and decision points established by the AHJ. Considerations include, but are not limited to, the short and long-term health effects to the responder from the operations, health effects of the event on victims, and capability of the AHJ to carry out life-saving missions. In addition to the information provided in annex section 6.5.2.2, materials provided in CDC 2007, will serve as reference material for enhancing the effectiveness of rescue operations.
7.3.1.4	*Emergency Decontamination Plan for Contaminated Victims:* Emergency decontamination will, in most situations, occur prior to the establishment of a formal decontamination corridor. Plans developed by AHJs should implement procedures allowing for immediate decontamination of victims and responders. Dry decontamination procedures are recommended initially. If follow-up screening identifies further contamination on victims or responders, wet decontamination procedures may be necessary to reduce contamination to acceptable levels. Planning considerations include, but are not limited to, the use of all available assets, choke points to direct victims through hastily established decontamination areas, and notification chains for prompt activation of public works and waste water staff regarding hazard potentials and characteristics. AHJs should evaluate the need to continue emergency decontamination efforts and move towards a formal decontamination corridor as the situation dictates. The physical process of immediately reducing contamination of individuals in potentially life-threatening situations with or without the formal establishment of a decontamination corridor is addressed in 2013 Edition NFPA 472 3.3.17.1l
7.3.1.5*(1)*	*Emergency Responder(s):* Decontamination corridors should be clearly marked and easily accessed by emergency responders. Plans developed for technical decontamination of emergency responders should include options for multiple stations (gross, technical, respiratory protection removal, clothing (PPE and personal), and the donning of replacement covering, etc.). Technical decontamination may include introduction of wet or dry methods to aid in decontamination. AHJs should predetermine requirements for monitoring in decontamination areas, capturing or diverting waste products for final treatment, or both, and sample collection for evidence and hazard analysis.
7.3.1.5*(2)*	*Contaminated Victim(s):* Decontamination plans should incorporate procedures necessary for contaminated victim handling including the identification of delivery points for contaminated injuries. Technical decontamination efforts for victims may be similar to those established for emergency response personnel, but should consider the lack of PPE available to civilian populations. AHJs should consider establishing separate decontamination corridors for victims and emergency responders. Considerations will include the need to provide law enforcement oversight and evaluation of victims, medical treatment and triage, and psychological support needed as a result of the incident and subsequent emergency response operations. As in plans developed for emergency responders, AHJs should determine requirements for monitoring in decontamination areas, capturing and/or diverting waste products for final treatment, and sample collection for evidence and hazard analysis. Some victims may be deceased. The CDC has issued guidelines for handling decedents (Wood, et al., 2007[D]). The reference provides guidance for radiation safety when the emergency response transitions to the management of deceased victims.
7.3.1.5*(3)*	*Equipment Processing:* Decontamination of equipment is the last stage of emergency response. Prior to beginning equipment decontamination the responsible parties should conduct a careful review to evaluate the ability of existing resources to decontaminate the equipment. Wet or dry decontamination methods may be considered.
7.3.1.5*(4)*	*Evidence Processing:* Evidence should be properly processed and packaged and containers holding the evidence will be decontaminated prior to leaving the hot zone according to protocols established by law enforcement authorities. Emergency responders conducting decontamination operations on evidence packaging should coordinate with on-scene law enforcement personnel to determine the appropriate methods for preserving evidence and documenting a chain of custody.

[A] Harper, F., Musolino, S., and Wente, W., "Realistic Radiological Dispersal Device Hazard Boundaries and Ramifications for Early Consequence Management Decisions," *Health Physics*, 93(1), 2007, pp. 1–16.

[B]Musolino and Harper, “Emergency Response Guidance for the First 48 Hours After the Outdoor Detonation of an Explosive Radiological Dispersion Device,” *Health Physics*, 90(4), 2006, pp. 377–385.
[C]Smith, J. M., Ansari, A., and Harper, F. T., “Hospital Management of Mass Radiological Casualties: Reassessing Exposures from Contaminated Victims of an Exploded Radiological Dispersal Device,” *Health Physics*, 89(5), 2005, pp. 513–520.
[D]Wood, C. M., DePaolo, F., and Whitaker, R. D., *Guidelines for Handling Decedents Contaminated with Radioactive Materials*, Centers for Disease Control and Prevention, 2007.
[E]CTOS—Center for Radiological/Nuclear Training at the Nevada National Security Site, *WMD Definitions for Use in the DHS Course Materials Developed by CTOS*, 2014.
[F]National Council on Radiation Protection and Measurement (NCRP), Responding to a Radiological or Nuclear Terrorism Incident: A Guide for Decision Makers, NCRP Report No. 165, 2010.
[G]ANSI N42.49A American National Standard for Performance Criteria for Alarming Electronic Personal Emergency Radiation Detectors (PERDs) for Exposure Control.
[H]EPA PAG Manual, Protective Actions Guides and Planning Guidance for Radiological Incidents, 2013 (Draft for Interim Use and Public Comment).
[I]Musolino, Stephen V., and Frederick T., Harper, Brooke Buddemeier, Michael Brown, and Richard Schlueck, “Updated Emergency Response Guidance for the First 48 Hours After the Outdoor Detonation of an Explosive Radiological Dispersal Device,” *Health Physics*, 2013, Volume 105, Number 1, Pages 65–73.

TABLE A1.2 Contamination Level Recommendations with Description and Activity Recommendations

Contamination Recommendation	Description	Activity
Beta and Gamma Contamination: Less than 1000 cpm (CRCPD 2006) 1000 Bq/cm^2 (60 000 dpm/cm^2) (NCRP Commentary No. 19) Greater than 1000 Bq/cm^2 (60 000 dpm/cm^2) (IAEA 2006)	Hot Zone boundary, outer perimeter of radiation hazard for exposure rate or surface contamination, or low radiation boundary	Restrict access to essential personnel; proceed with emergency operations (life-saving, fire fighting, etc.); shelter/evacuate public, isolate area, and minimize responder time spent in the area
Alpha Contamination: Less than 1000 cpm (CRCPD 2006) 100 Bq/cm^2 (6000 dpm/cm^2) (NCRP Commentary No. 19) Greater than 100 Bq/cm^2 (6000 dpm/cm^2) (IAEA 2006)	Hot Zone boundary, outer perimeter of radiation hazard for exposure rate or surface contamination, or low radiation boundary	Restrict access to essential personnel; proceed with emergency operations (life-saving, fire fighting, etc.); shelter/evacuate public, isolate area, and minimize responder time spent in the area

TABLE A1.3 Response Worker Guidelines (EPA 2013)

Guideline	Activity	Condition
5 rem (50 mSv)	All occupational exposures.	All reasonably achievable actions have been taken to minimize dose.
10 rem (100 mSv)[A]	Protecting valuable property necessary for public welfare (for example, a power plant).	Exceeding 5 rem (50 mSv) unavoidable and all appropriate actions taken to reduce dose. Monitoring available to project or measure dose.
25 rem (250 mSv)[B]	Lifesaving or protection of large populations	Exceeding 5 rem (50 mSv) unavoidable and all appropriate actions taken to reduce dose. Monitoring available to project or measure dose.

[A]For potential doses >5 rem (50 mSv), medical monitoring programs should be considered.
[B]In the case of a very large incident, such as an IND, incident commanders may need to consider raising the property and lifesaving response worker guidelines to prevent further loss of life and massive spread of destruction.

These emergency worker guidelines were developed for a wide range of possible radiological scenarios. Therefore, the 5, 10, and 25 rem (50, 100, and 250 mSv) guidelines (Table X5.1) should not be viewed as inflexible limits applicable to the response. Because of the range of impacts and case-specific information needed, it is impossible to develop a single turn-back dose level for all responders to use in all events, especially those that involve lifesaving operations. Indeed, with proper preparedness measures (training, personal protective equipment (PPE), etc.) most radiological emergencies addressed by this practice, even lifesaving operations, may be manageable within the 5 rem (50 mSv) guideline. (EPA PAG 2013.)

Similarly the NCRP and ICRP raise the possibility that emergency responders might receive a dose that approaches or exceeds 50 rem (0.5 Sv) to a large portion of the body in a short time. If lifesaving emergency responder exposures approach 50 rem (0.5 Sv), emergency responders must be made fully aware of both the acute and the chronic (cancer) risks of such exposure.

It should be emphasized that dose to the individual responder should always be managed to the lowest possible level. ALARA principles should always prevail and if only defensive operations are required, responder dose should not require management beyond the 5 rem (0.05 Sv) guideline for any emergency activity. Estimated dose to responder should be calculated and tracked through the established documentation pathway approved by the IC. It is important for responders to understand both the deterministic (acute or near-term) and the stochastic (cancer or long-term) effects of radiation. Table A1.3 provides a summary of deterministic (acute) effects from radiation at various levels within the bounds of dose relevant to this practice (NCRP Report No. 138). The average baseline risk of adult cancer deaths is 20 % or 200 deaths per 1000 people. The risk is believed to be greater for younger ages exposed. For example, the estimated risk to 20 to 30 year olds at 25 rem (0.25 Sv) is 1.75 %, which is about twice as large as the risk for 40 to 50 year olds (0.5 %).

TABLE A1.4 Medical Aspects of Radiation Injury (0–125 rem)[A]

Dose	Initial Symptoms	Initial Symptoms Interval Onset–End	Medical Problems	Indicated Medical Treatment	Disposition without Medical Care	Disposition with Medical Care	Clinical Remarks
0–35 rem (0–0.35 Sv)	None	N/A	N/A	Reassurance. Counseling at redeployment.	Home/Duty	Home/Duty	Potential for anxiety
35–75 rem (0.35–0.75 Sv)	Nausea, mild headache	ONSET: 6 h END: 12 h	N/A	Reassurance. Counseling at redeployment.	Home/Duty	Home/Duty	Mild lymphocyte depression with 24 h
75–125 rem (0.75–1.25 Sv)	Transient mild nausea. Vomiting in 5–30 % of personnel	ONSET: 3–5 h END: 24 h	Potential for delayed traumatic and surgical wound healing. Minimal clinical effect.	Debridement and primary closure of any and all wounds. No delayed surgery.	No further radiation exposure or elective surgery.	No further radiation exposure.	Moderate drop in lymphocyte, platelet and granulocyte counts. Increased susceptibility to opportunistic pathogens.

[A] For the purposes of emergency response, a common approximation for x- and gamma-radiation is that an exposure of 1 R produces a dose equivalent of about 1 rem (0.01 Sv).

TABLE A1.5 Typical Occupancies and Relation to Likelihood of Radioactive Material Presence

Type Occupancy	Radioactive Material Likely	Radioactive Material Unlikely
Assembly		X
Business		X
Educational		X[A]
Factory and Industrial	X	
High-Hazard	X	
Institutional	X	
Mercantile		X
Residential		X
Storage		X
Utility and Miscellaneous		X

[A] At primary and secondary institutions, radioactive material unlikely; however at post-secondary institutions radioactive material is likely, especially in laboratory facilities.

APPENDIXES

(Nonmandatory Information)

X1. RADIOLOGICAL EMERGENCY RESPONSE ZONES

X1.1 See Figs. X1.1 and X1.2.

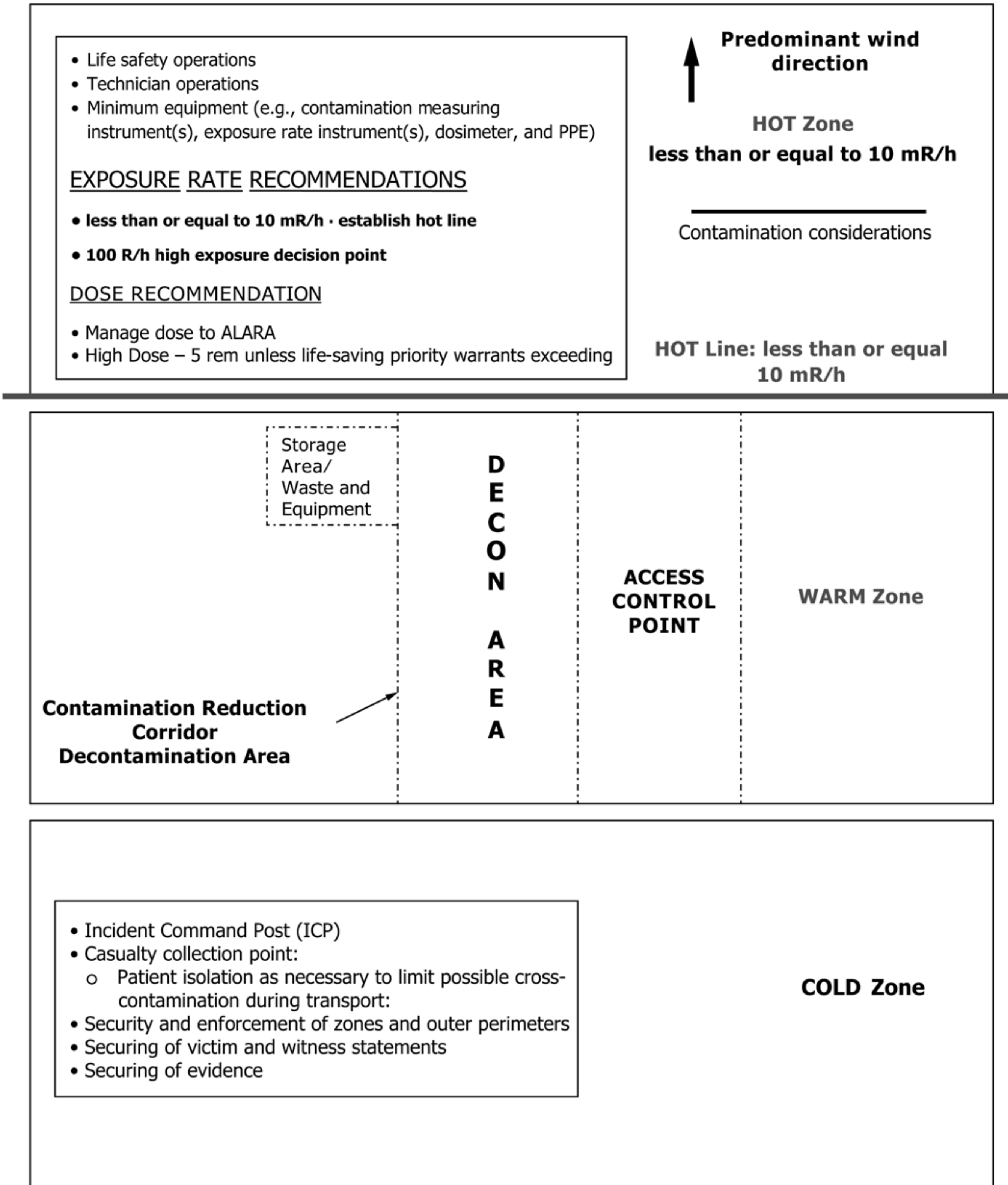

FIG. X1.1 Detailed Radiological Emergency Response Zones

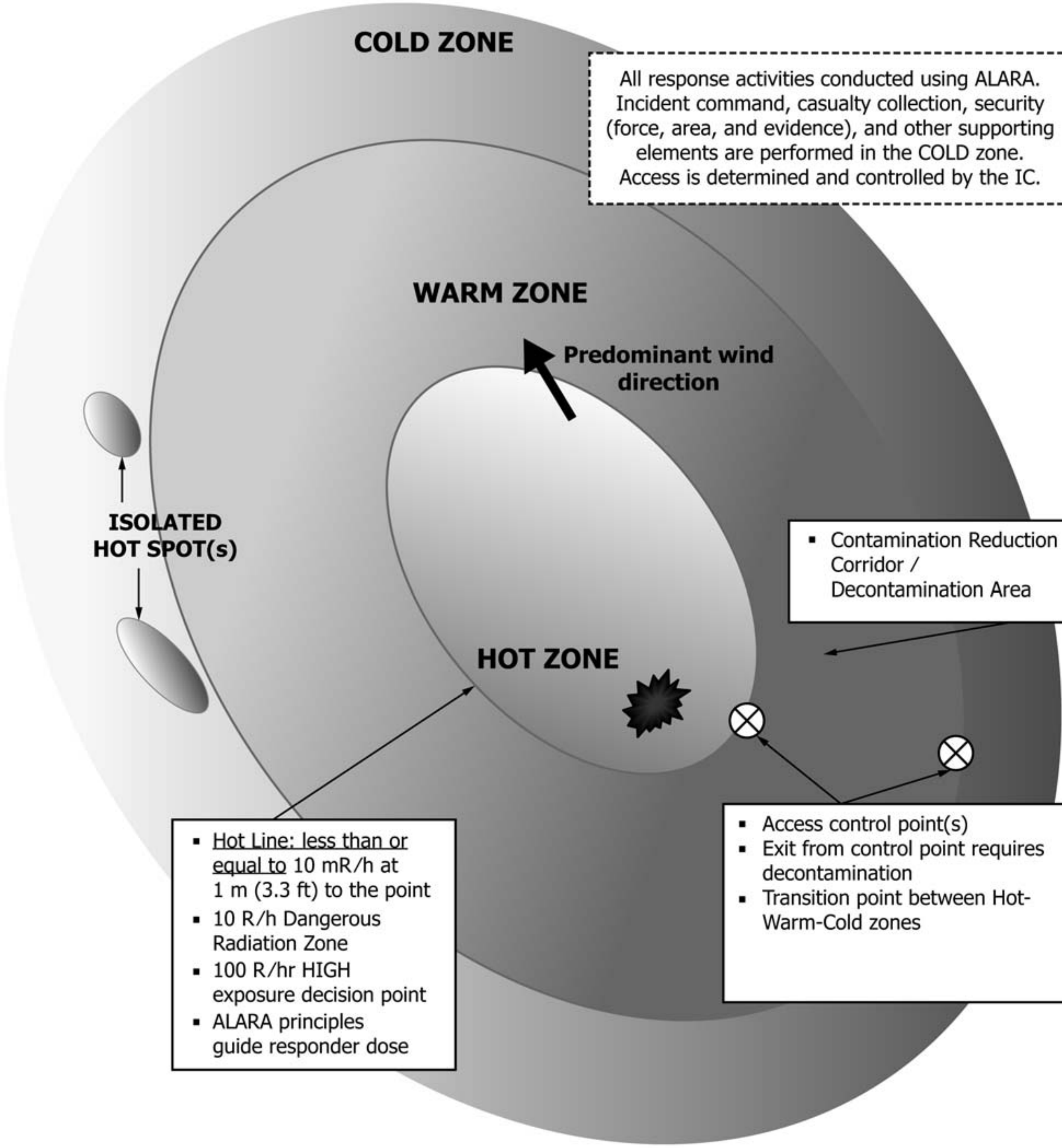

FIG. X1.2 General Radiological Emergency Response Zones

X2. RADIATION CONTROL ZONE RECOMMENDATIONS AND SUGGESTED ACTIVITIES [NCRP Report No. 165 (2010), NCRP Commentary No. 19 (2005), CRCPD 2006, and IAEA 2006]

X2.1 See Table X2.1.

TABLE X2.1 Exposure Rate Decision Point Summary with Associated Zones, Activity, and Stay Time Recommendations

Decision Exposure Rate	Zone or Hazard Designation	Activities
Background		No restrictions. The best location for IC and decontamination activities.
Less than 10 mR/h (NCRP Report No. 165)	Cold Zone	Take measures to reduce cross contamination
10 mR/h (NCRP Commentary No. 19; NCRP Report No. 165); less than or equal to 10 mR/h (CRCPD 2006); 10 mrem/h at 1 m (IAEA 2006)	Hot Zone; Outer perimeter of radiation hazard for exposure rate or surface contamination, or low radiation boundary	Restrict access to essential individuals. Initial decontamination of emergency responders should occur near the outer boundary of this area. Uninjured personnel within this zone at the time of an RDD explosion can be directed to proceed directly home to shower if resources do not permit contamination surveying at the scene. For small RDDs this may be the only zone that exists.
100 mR/h (CRCPD 2006)		Restrict access to only authorized personnel. Personal dosimetry should be worn. Serves as a buffer zone/transition area between the hot line and higher hazard radiation area. People within this zone at the time of the explosion should be surveyed for contamination as they proceed through the decontamination corridor or an ad hoc screening area before being released. This is likely the highest radiation zone for an RDD.
1 R/h (CRCPD 2006)		Restrict access to authorized personnel with specific critical tasks such as firefighting, medical assistance, rescue, extrication, and other time-sensitive activities. Personal dosimetry should be worn. People within this zone at the time of the explosion should be surveyed for contamination as they proceed through the decontamination corridor or an ad hoc screening area before being released.
10 R/hour (NCRP Report No. 165; NCRP Commentary No. 19; CRCPD 2006IAEA)	Dangerous Radiation Zone, Inner perimeter, high radiation hazard	This area, located within the high radiation zone, is restricted to the most critical activities, such as lifesaving. Personal dosimetry required, although one monitor for several responders is acceptable if they remain near the person with the monitor. Limit time spent in this area to avoid acute radiation sickness. People within this zone at the time of the explosion must be surveyed for contamination before being released.

X3. STAY TIME TABLE TO MANAGE EMERGENCY RESPONSE DOSE

X3.1 See Fig. X3.1.

Exposure Rate*	TOTAL DOSE[9, 10]								
	100 mrem	1 rem	5 rem	10 rem	25 rem	50 rem	100 rem	125 rem	150 rem
1 mR/h	4 day	6 wk	7 mo	14 mo	2.8 yr	5.7 yr	11.4 yr	14.3 yr	17.1 yr
2 mR/h	50 h	3 wk	3.5 mo	7 mo	1.4 yr	2.9 yr	5.7 yr	7.1 yr	8.6 yr
5 mR/h	20 h	8.3 day	6 wk	2.8 mo	7 mo	1.2 yr	2.3 yr	2.8 yr	3.4 yr
10 mR/h	10 h	4 day	3 wk	6 wk	3.5 mo	6.9 mo	14 mo	1.4 yr	1.7 yr
25 mR/h	4 h	40 h	8.3 day	16.6 day	6 wk	2.8 mo	5.6 mo	7 mo	8.3 mo
50 mR/h	2 h	20 h	4 day	8.3 day	3 wk	6.0 wk	2.8 mo	3.5 mo	4.2 mo
100 mR/h	1 h	10 h	50 h	4 day	10 day	20.8 d	6 wk	7.5 wk	2 mo
200 mR/h	30 min	5 h	25 h	50 h	5 day	10.4 d	3 wk	3.7 wk	1 mo
500 mR/h	12 min	2 h	10 h	20 h	50 h	4.1 d	8.3 day	10.4 day	12.5 day
1 R/h	6 min	1 h	5 h	10 h	25 h	2.1 d	4 day	5.2 day	6.2 day
2 R/h	3 min	30 min	2.5 h	5 h	12.5 h	1.0 d	50 h	2.6 day	3 day
5 R/h	72 sec	12 min	1 h	2 h	5 h	10 h	20 h	25 h	30 h
10 R/h	36 sec	6 min	30 min	1 h	2.5 h	5 h	10 h	12.5 h	15 h
25 R/h	14.4 sec	2.4 min	12 min	24 min	1 h	2 h	4 h	5 h	6 h
50 R/h	7.2 sec	72 sec	6 min	12 min	30 min	1 h	2 h	2.5 h	3 h
100 R/h	3.6 sec	36 sec	3 min	6 min	15 min	30 min	60 min	75 min	1.5 h
200 R/h	1.8 sec	18 sec	90 sec	3 min	7.5 min	15 min	30 min	37.5 min	45 min

NOTE 1—Use this tool as a general guide. Responders will not advance to a rate in the table instantly. Radiation levels will irregularly go up and down. Monitor dosimeters and track time using low dose paths.

[9] In practical terms, when x-ray and gamma radiations are involved (NCRP, 2005):

$$1\ \text{R}\ (\text{exposure in air}) \doteq 1\ \text{rem}\ (\text{dose to the body})$$

[10] The "total dose" does not include doses from internal or external contamination on the clothes/body, if any exist. The chart only estimates the time to dose for external x-ray and gamma radiation sources.

FIG. X3.1 Stay Time Table to Manage Emergency Response Dose

X4. TIME, DISTANCE, SHIELDING (TDS) CONCEPTS

X4.1 See Figs. X4.1-X4.3.

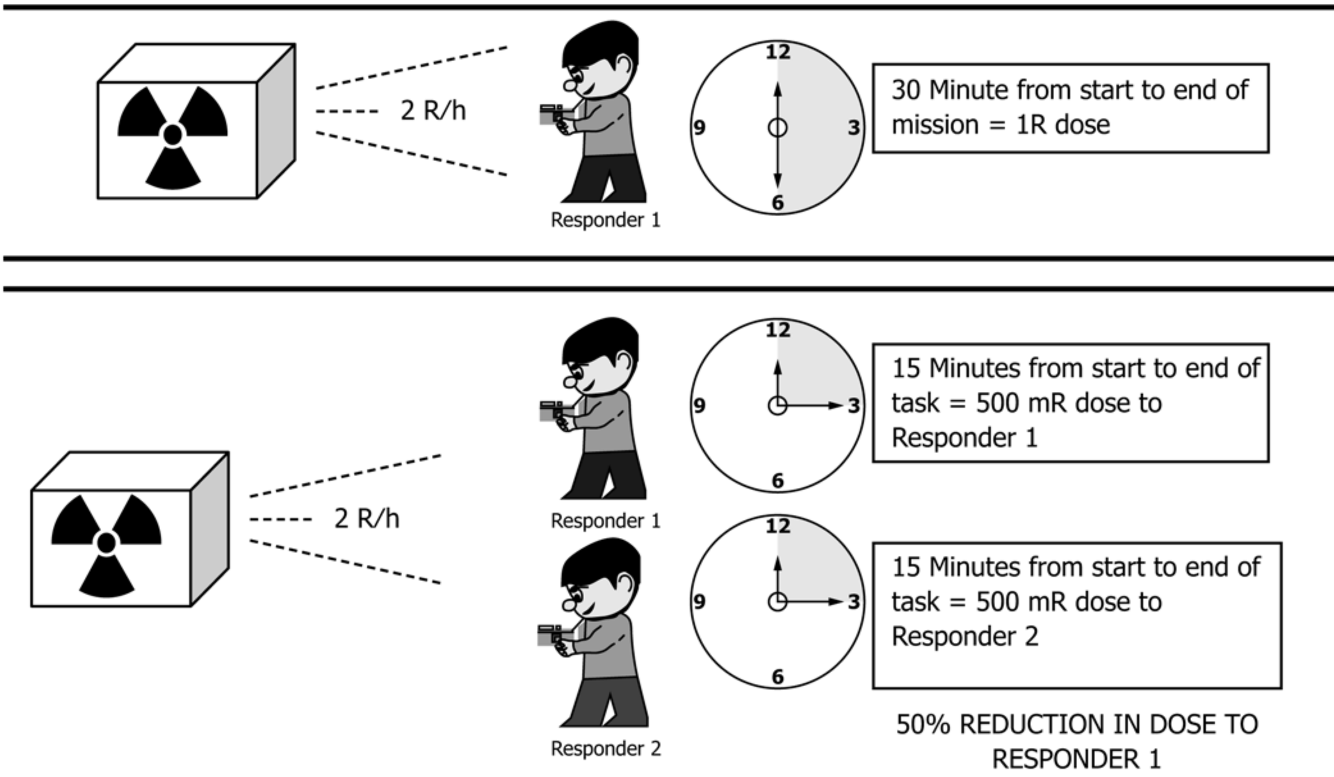

FIG. X4.1 Time—Minimizing Responder Dose Using Staff Rotation and Split Tasks for a Specific Mission

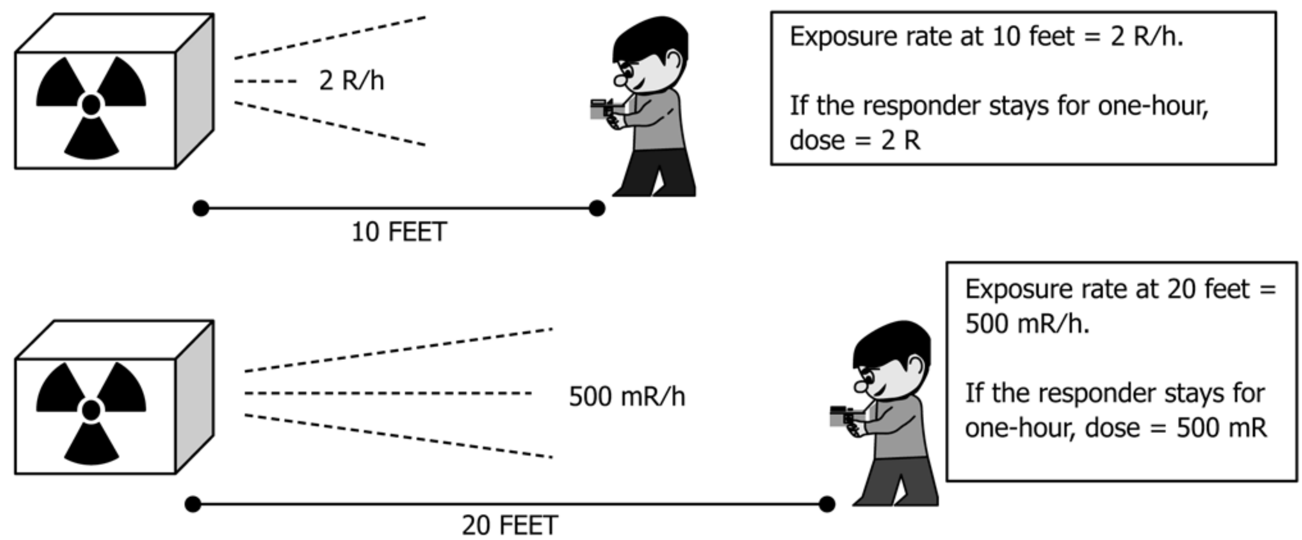

FIG. X4.2 Distance—Minimizing Responder Dose Using Distance as a Reduction Method

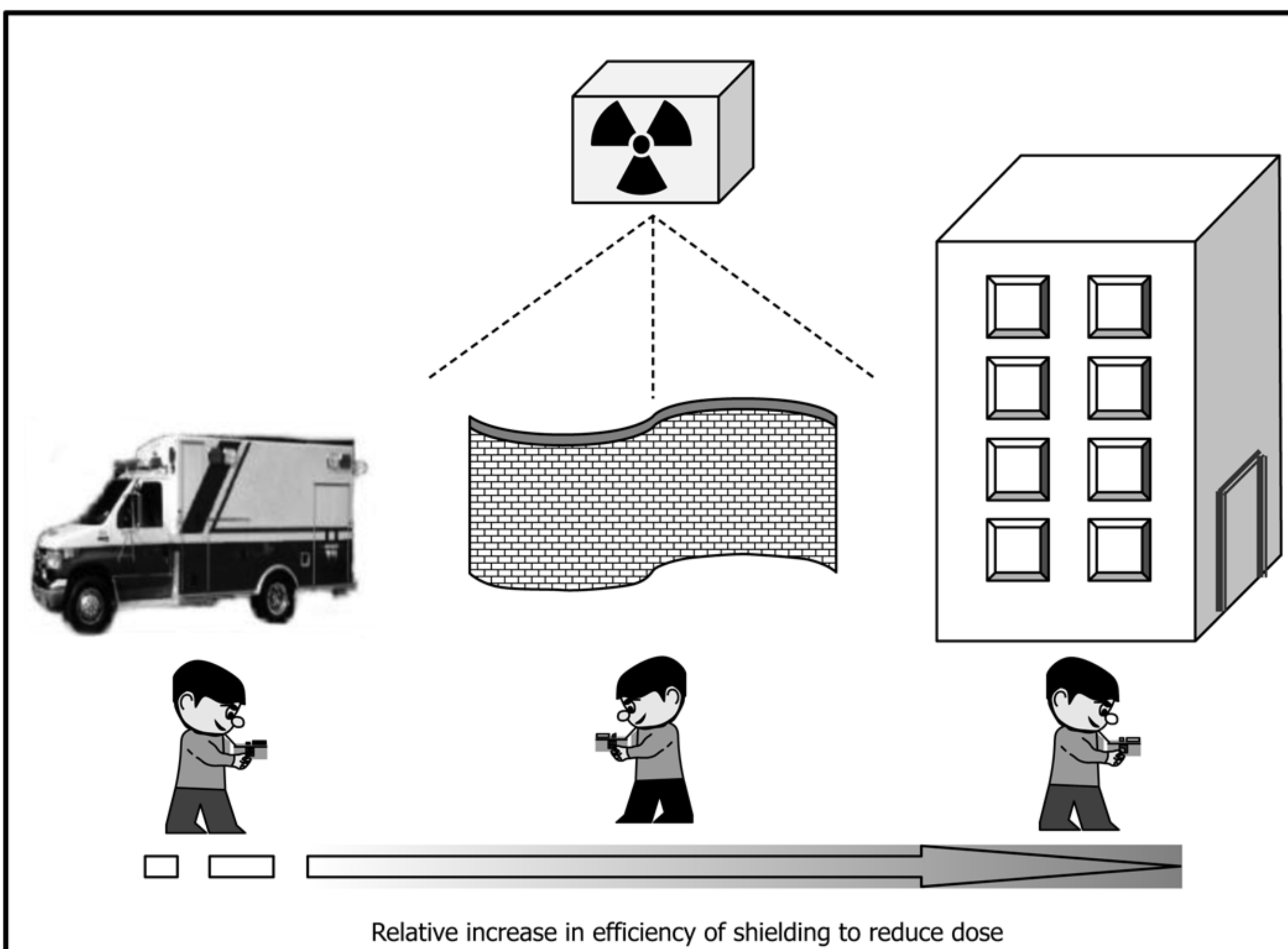

FIG. X4.3 Shielding—Minimizing Responder Dose Using Available Shielding as a Reduction Method

X5. DOSE CONTROL LOG

X5.1 See Table X5.1.

TABLE X5.1 Dose Control Log

(A) Pg ______ of ______ (B) Organization ______________________ (C) DCO/ECO ______________________

(1) PACKET NO. & DATE ISSUED	(2) NAME - - - - - - - & - - - - - - - SOCIAL SECURITY NUMBER	(3) ALARMING DOSIMETER SERIAL NUMBER	(4) DIRECT READ SERIAL NUMBER	(5) RAD DOSE RECORD CARD	(6) RESPONDER SIGNATURE (Number 2)	(7) TURN-IN (CIRCLE) - - - & - - - DATE	(8) DATE TO DCO OR ECO	(9) ENDING DOSE ON No. 4 / 7	(10) SAFETY OFFICER INITIALS
1						3 4 5			
2						3 4 5			
3						3 4 5			
4						3 4 5			
5						3 4 5			
6						3 4 5			
7						3 4 5			
8						3 4 5			
9						3 4 5			
10						3 4 5			

COMPLETED BY (PRINT): ________________________________ DATE: ______________ SIGNATURE: ________________________________

Heading:
(A) Enter the log (page) number sequentially by calendar year, for example, 1/08 of 4/08.
(B) Enter the organization name.
(C) Enter the name of the Dosimetry Control Officer (DCO) or Exposure Control Officer (ECO).
Column (1): Enter the dosimetry packet number or dosimeter number and the date packets or dosimetry was issued in the spaces provided.
Column (2): Print the name and Social Security number of the packet recipient in the spaces provided.
Column (3): Enter the alarming dosimeter's serial number.
Column (4): Enter the direct read dosimeter's serial number.
Column (5): If a Radiation Dose Record/Instruction Card is issued, and if the packet recipient completes the administrative portion of the card, and reads and understands the instructions, place a check mark in the space provided.
Column (6): Obtain the signature of the recipient or responder the packet or dosimetry is issued to.
Column (7): Numbers permanently entered above the dividing line correspond to the column numbers describing items 3 through 6. Circle the appropriate item number, when the packet is returned. In the space provided below the dividing line, enter the date these items were received. If discrepancies exist with the equipment listed in columns 3 through 5, the DCO / ECO should maintain explanatory notes. Documentation should be retained by the Planning Section at the end of the incident.
Column (8): Enter the date the alarming dosimeter or direct read dosimeter was received and accounted for by the DCO or ECO.
Column (9): Enter the ending dose received or recorded by the responder on the alarming and/or direct read dosimeter.
Column (10): Obtain the Safety Officer's signature or initials to verify doses are accurately recorded and exposure control measures can be implemented as necessary.
Bottom of Page: Enter the printed name, date and signature of the person completing the DCO / ECO Dose Control; Log.

X6. RADIATION DOSE RECORD

X6.1 See Fig. X6.1.

Radiation Dose Record

NAME ______________________________

SOC. SEC. NO. ______________________

ORGANIZATION ______________________

DOSIMETER TYPE AND S/N

________________ / ________________

INSTRUMENT TYPE AND S/N

________________ / ________________

BACKGROUND READING ______________

TEAM MEMBER'S NAME ________________ (IF APPLICABLE)

DATE(S) OF EXPOSURE(S)	DAILY DOSES(S)		TOTAL DOSE TO DATE
	START	ENDING	

ALARA to manage dose

DOSIMETRY INSTRUCTIONS

Always wear dosimetry when the possibility of a radiation exposure exists. Follow the instructions listed below. If you lose the dosimetry, or have any questions, contact the Dosimetry Control Officer (DCO) or Exposure Control Officer (ECO) immediately.

DOSIMETERS

1. Enter the personal and equipment information on the Dose Record Card.
2. At the start of each mission/shift, ensure the dosimeter is zeroed or set according to the IC's directives.
3. If using alarming dosimetry, verify that alarm set points are corrective and activated.
4. Enter the date of exposure, read the dosimeter, and record the starting dose in the space provided.
5. Clip the dosimeter to an outer garment, above the waist. Avoid dropping or jarring.
6. Read the dosimeter as directed.
7. Report accumulated dose on the dosimeter in accordance with directions.
8. When using dosimetry, notify the DCO or ECO immediately if notification levels are reached.
9. When using alarming dosimetry, notify the DCO or ECO immediately if the dose alarm activates.
10. Read and record dosimeter readings at the end of each mission/shift.
11. Return dosimeter and Dose Record as directed.

RADIOLOGICAL INSTRUMENTS

1. Ensure the instrument is operable in accordance with procedures.
2. Obtain, report, and record an average background reading away from any known or potential sources of exposure.
3. Monitor slowly allowing for an adequate amount of time for the instrument to respond.
4. Obtain, report, and record readings as directed by the DCO or ECO.

ALARA to manage exposure

FIG. X6.1 Radiation Dose Record and Dosimetry Instructions

X7. RADIOLOGICAL ASSESSMENT

X7.1 See Fig. X7.1.

DATE: ________ **APPENDIX G: RADIOLOGICAL ASSESSMENT** **TIME: ________**

☐ Identify wind direction, Remain Uphill/Upwind: Wind Direction: From To Wind Speed: mph

☐ Attempt to identify hazard and location:

☐ Perform initial hazard assessment

Placard(s): Exp: ____ Gases: ____ Fl. Liq: ____ Fl. Sol: ____ Oxidizers: ____

Poison: ____ Rad: ____ Corr: ____ Misc: ____

NFPA 704: Flam: ____ Health: ____ Resisivity: ____ Special Hazards: ________

Mode of Transportation: Ground ____ Rail ____ Air ____ Water ____ Other ________

Fixed Facility: Govt. ____ Private ____ Military ____ Type : Industrial ____ Comm. ____ Public ____

Chemicals Stored On-Site: Type/Qnty ____/____ Type/Qnty ____/____

Type/Qnty ____/____ Type/Qnty ____/____

Site Safety Officer: Name ________ Tel.# ________

Site Security Officer: Name ________ Tel.# ________

HAZARD IDENTIFICATION

Shipping Papers: ____ Manifest: ____ Bill of Laden: ____ Chem. Inventory: ____

☐ Obtain background radiation reading: ____ Instrument Type ________ / Detector________

INSTRUMENT READINGS

Radiological: BKG ____ Instrument Type ________ / Detector________

Radiological Readings or Alarms: Exposure Rate ________ Count Rate ________

Chemical:

Instrument Readings or Alarms: LEL ____ O2 ____ Other ________

Instrument Type ________ / Detector(s)________

☐ Identify and document visual indicators / victim and animal symptoms / witness statements

INDICATORS/WITNESSES

Shielding Materials: Lead ____ Plastic/Paraffin ____ Metallic Debris ____ Other ________

Special Containers: Cylinders: ____ Totes: ____ Boxes: ____ Type A/B Packages: ____

Cargo Tank/Type: ________ Industrial Devices: ________

Victims Signs/Symptoms: ________________

Victims Signs/Symptoms: ________________

Victims Signs/Symptoms: ________________

Animal/Wildlife Signs/Symptoms: Type ________ Dead ____ Dying ____ Symptom ________

DOCUMENT AND RETAIN VICTIM / WITNESS STATEMENTS FOR OFFICIAL USE

FIG. X7.1 Radiological Assessment

X8. RADIOLOGICAL EMERGENCY RESPONSE GUIDELINES

INTRODUCTION

This appendix can be freely modified to build a guidance document specific to a community using this standard practice.

X8.1 Background

X8.1.1 This document provides basic guidance for emergency responders operating in the early phase of a radiological incident (0 to 24 h or until specialized resources arrive on scene if they are requested).

X8.1.2 This guidance is directed to emergency responders at the NFPA 472 Core Operations Level with Mission Specific capabilities as necessary for the assigned mission.

X8.1.3 This guidance does not include provisions for improvised nuclear devices.

X8.1.4 Jurisdictions using the guidance should incorporate local procedures for notification and requests for assistance from specialized radiological response assets.

X8.1.5 This guidance is to be used jointly with local response plans.

X8.1.6 TRACEM (Thermal, Radiological, Asphyxiant, Chemical, Etiological, Mechanical) issues were considered throughout. While response to radiological hazards is the focus of this standard, responders must consider all hazards during a response; it is possible that non-radiological hazards may present a greater risk than radiological hazards at an incident.

X8.2 Prerequisites

X8.2.1 *Response Plan*—The minimum elements of the plan should:

X8.2.1.1 Classify the response as to whether:

(1) Radioactive material is contained and does not presently pose an exposure risk to human health or the environment, or

(2) Radioactive material has been released or has the potential to be released thereby presenting an exposure hazard.

X8.2.1.2 Delineate defensive and offensive operations:

(1) In defensive operations where victim life safety is not an issue and responder life safety is the main concern, time is sufficient to step back and develop a plan that reduces or negates radiation exposure. Defensive operation plans establish:

(a) Notification details such as local, state, and federal law enforcement agencies including the FBI; local and state emergency management agencies and EOCs; federal agencies such as Department of Homeland Security's Federal Emergency Management Agency, Department of Energy's Radiological Assistance Program, the Nuclear Regulatory Commission, Agreement States, the Environmental Protection Agency, health and environmental departments, hospitals, and others as necessary.

(b) Radiation hot zone including exposure rate and surface contamination levels. The maximum exposure rate for the hot line is ≤10 mR/h (0.1 mSv/h) at 1 m (3.3 ft).

(c) Incident Command Post (ICP), personnel and equipment, and decontamination area locations outside of hot zone.

(d) Decontamination plan to safely and effectively remove or lower contamination on operational personnel and civilian victims to an acceptable level. Protection of emergency responders, support personnel, and medical staff is the highest priority on-scene. Care should be taken to recognize the potential for cross contamination and the need for evidence preservation, and appropriate safety precautions should be taken throughout the incident.

(2) Life-safety operations are top priority in offensive operations. Offensive operations plans include the same details as defensive plans and the following:

(a) The low exposure rate decision point is less than or equal to 10 mR/h at 1 m (3.3 ft).

(b) The high exposure rate decision point is not to exceed 100 R/h when reasonably achievable; above 100 R/h the IC should only commit informed, consenting responders to short duration life-saving activities.

(c) Maximum dose to emergency responders not to exceed 50 rem when reasonably achievable.

(d) The stay time table shown in Fig. X3.1 can be used to manage responder dose.

X8.2.2 *Resources:*

X8.2.2.1 An instrument, or combination of instruments, able to measure alpha, beta, and gamma radiation with sensitivity equivalent to a pancake GM instrument.

X8.2.2.2 An instrument or combination of instruments able to measure the range of exposure rate of 0.005 mR/h to 100 R/h.

X8.2.2.3 One dosimeter per team member able to measure the penetrating radiation (option—include programmable alarm function) *or* one dosimeter per team to measure penetrating radiation (option—include programmable alarm function).

X8.2.2.4 PPE requirements (describe based on requirement and discipline).

X8.2.3 *Training:*

X8.2.3.1 NIMS ICS,

X8.2.3.2 29 CFR 1910.120 (q) and General Duty Clause,

X8.2.3.3 Any federal, state, local, or tribal regulatory requirements that apply, and

X8.2.3.4 NFPA 472–2008.

(1) Chapter 5. Core Competencies.

(2) Chapter 6. Mission Specific Competencies (minimum PPE, monitoring, and detection).

X8.2.4 *Safety:*

X8.2.4.1 Ensure proper equipment has been assembled and maintained for mission.

X8.2.4.2 Monitor strategic command operations; ensure use of self protection concepts.

(1) ALARA principles:

(a) Time: minimize time near sources of radiation; AHJs should consider the use of staff rotation to reduce responder dose.

(b) Distance: maximize distance; doubling the distance from a source of gamma radiation cuts exposure by one-fourth.

(c) Shielding: maximize use of shielding; shielding can be supplied from buildings, vehicles, earth barriers, and other potential sources.

(2) Determine the feasibility of life safety operations based on elapsed time, geographic distance of the victim from source, exposure rate, and difficulty of life-saving operations. The feasibility of life safety operations can be categorized by the AHJ using the following guidance:

(a) Elapsed time: the time from notification of event or awareness of a radiological threat, to the time life safety operations begin.

(b) Distance from source: the physical distance a victim is from a source of ionizing radiation, coupled with the physical distance a responder must travel to safely perform life-saving treatment or rescue.

(c) Exposure rate: the amount of exposure the responder and victim are estimated to receive from the source of radiation given elapsed time and the geographic distance considerations. Exposure rates should be verified and routinely evaluated for changes in conditions that may decrease or increase the dose to responder and victim.

(d) Difficulty of life-saving operations: determination by the AHJ on type (simple or technical) of rescue necessary; time required for safe rescue operations; number of victims requiring rescue; status of victims; availability of resources to carry out rescue operations (trained personnel, equipment, and commodities); geographic distance required for victim assessment, transport, and safe treatment; and the scope (size) of the area impacted by the event.

X8.2.4.3 Develop site plans and document them as defined in 29 CFR 1910.120 (q) including dose reports, dose report with associated injury report, personnel dosimeter logs.

X8.3 Radiological Emergency Response

X8.3.1 *Analyze the Response:*

X8.3.1.1 Assess scene and evaluate for on-scene indicators such as:

(1) Occupancies or locations: It would not be uncommon for responders to encounter unmarked or unlabeled radioactive sources at industrial, construction, mercantile, or medical occupancies; it would be unlikely that responders would encounter radioactive sources at assembly, educational[23] (primary or secondary), correction, or storage facilities.

(2) Containers or radioactive material packages: Federal regulations place strict administrative controls on the transport of radioactive material; packages must be marked and labeled so responders can easily recognize the package type, identify the radioactive material content and activity of the material inside the package.

(3) Natural sources including building materials: Some building materials have inherent radioactive components; building construction types that use large quantities of concrete, granite, or ceramic tile may have increased levels of background radiation; more typical wood or steel frame constructions are less likely to have increased levels of background radiation.

(4) Shipping documents: Radioactive material is required to be accompanied with paperwork that documents the shipment. Required items include: proper shipping name, emergency telephone number, chemical and physical form of the material, the shipper and receiver's contact information.

(5) Signs and symptoms: It takes a very large dose of radiation to produce immediate outwardly visible biological effects; persons who receive a large dose of radiation in a short period of time may suffer the effects of radiation sickness or radiation toxicity; the symptoms are nonspecific and consist of nausea, vomiting, diarrhea, anorexia and malaise.

(6) Intelligence information: Response agencies may be activated based on intelligence gathering by local, state or federal law enforcement agencies to confirm or deny suspicions (for example, check for the presence of radioactive materials), and implement protective actions if sources are considered reliable or probable.

(7) Monitoring and detection information: Responders using required equipment will be collecting information to assess the scene.

X8.3.1.2 Determine if incident is accidental or intentional:

(1) Accidental releases of radioactive material can occur at a wide variety of locations or as a result of transportation accidents. The following are examples of potentially accidental radiological responses:

(a) Release at a facility such as a medical, research, construction, or industrial site.

(b) Release in transport.

(c) Breach in package.

(d) Inappropriate packaging for the material.

(e) Readings above transport index.

(f) Package containing radioactive material that is involved in a fire.

(g) Orphan source.

(h) Malfunctioning radiography source; this may occur at a site where radioactive materials are not normally found.

(2) Intentional releases of radioactive material can occur anywhere as a result of malicious or criminal acts. A situation that appears accidental could indeed be malicious. Additional concerns of an intentional release are hazards of a secondary device and crime scene/evidence preservation. Examples of intentional radiological releases include:

(a) Radiological dispersal devices (RDD): An RDD is a device intended to disperse radioactive material for malicious reasons, but it is not capable of producing a nuclear yield and is not an atomic bomb. An RDD typically uses the force of conventional explosives to scatter radioactive material. The detonation of a large-scale explosive device near a target that

[23] Post-secondary educational institutions with research facilities will likely have radioactive sources.

contains a large amount of radioactive material could cause a dispersion of that material. Depending on wind speed and direction, the radioactive material could be spread over a large area. Because fires, which would likely occur following an RDD event, could further spread radioactive material responders should extinguish fires as soon as it is safe to do so.

(b) Radiological exposure devices (RED): A RED is a powerful beta-, gamma-, or neutron-emitting radioactive source that can be placed in a high profile location, such as a high-traffic urban area or government facility, which could expose a large number of people to the intense radioactive source. REDs can also be used to target specific individuals or harm a limited number of people over a long period of time.

(c) Other deliberate acts of radioactive material release or exposure: A terrorist's use of radioactive materials can take other forms, in which radioactive material is distributed. Radiation can be dispensed through the use of inexpensive and common items such as pressurized containers, fans, ventilation systems, and mechanical devices to spread contamination. Non-explosive RDDs are often referred to as radiological dispersal weapons (RDWs) or simple radiological dispersal devices (SRDD).

X8.3.1.3 Determine the scope of the response:

(1) Collect hazard information from various resources:

(a) Human sources (for example, witnesses, victims, subject matter experts (for example, radiation authorities), responsible party).

(b) Reference materials (for example, databases, written materials, modeling data).

(2) Identify environmental conditions that have the potential to affect the response including geography, rural and urban environments, topography, and atmospheric/weather considerations.

(3) Survey for radiation and contamination and monitor surroundings.

(4) Recognize and identify additional hazards (TRACEM).

X8.3.1.4 Work with IC to predict the outcome as required: The IC will interpret information and predict the likely outcome of the response, including potential harm, through the use of scene analysis and situational awareness. This interpretation will be used to guide response directives provided to operational responders.

X8.3.2 *Operational Response Planning Considerations:*

X8.3.2.1 Describe response actions according to the following for both accidental and intentional incidents:

(1) Self-protection concepts including ALARA principles: time, distance, shielding.

(2) Required resources including contamination monitoring instrument, exposure rate instrument, dosimeter, and PPE.

(3) Life safety operations: determine the feasibility of rescue operations based on elapsed time, geographical distance from source, exposure rate, and difficulty of life-saving operations.

(4) Emergency decontamination plan for contaminated victim(s).

(5) Technical decontamination plan for emergency responder(s), contaminated victim(s), equipment processing, and evidence processing.

X8.3.2.2 Additional actions for planning the response to an intentional radiation incident/emergency are as follows:

(1) Provide security through law enforcement for crime scene perimeter, crime scene, command post, staging area, and safe refuge area.

(2) Monitor for secondary threats.

(3) Preserve evidence.

(4) Conduct investigation.

X8.3.2.3 Establish the following:

(1) Type of radiological response; is radioactive material contained and not presenting immediate hazard *or* radioactive material has been released or has the potential to be released thereby presenting an exposure hazard.

(a) If radioactive source presents or potentially presents a hazard, differentiate between defensive and offensive operations.

(b) If radioactive source presents or potentially presents a hazard, determine if incident is accidental or intentional. If intentional, monitor for secondary threats.

(2) Hot line: not to exceed 10 mR/h at 1 m (3.3 ft) from the ground, when reasonably achievable and contamination considerations should be evaluated.

(3) ICP, personnel, equipment, and decontamination operations in an area where there is no contamination; if contamination is present levels should be less than 1000 cpm measured 1 to 2 in. from the ground with a pancake GM probe, or instrument with equivalent sensitivity.

(4) Decision points for offensive operations (life safety operations).

(a) Dose: not to exceed 50 rem when reasonably achievable.

(b) Low exposure rate: not to exceed 10 mR/h at 1 m (3.3 ft) when reasonably achievable.

(c) High exposure rate: not to exceed 100 R/h when reasonably achievable.

X8.3.2.4 Describe actions to be taken based on analysis and AHJ's emergency response plans and procedures for the following:

(1) Notification: appropriate notifications should be made to emergency response and regulatory agencies in accordance with AHJ plans.

(2) Request specialized resources such as subject matter experts and medical, law enforcement, fire service, and state/local radiation professionals.

(3) Protective action considerations should include:

(a) Evacuation,

(b) Shelter in Place, and

(c) Scene Control.

(4) Establish documentation requirements.

X8.3.3 *Implement Radiological Emergency Response*—The following descriptions are directly tied to the response flowchart shown in Fig. X8.1.

X8.3.3.1 Responders dispatched to an incident scene are assessing the situation to monitor for possible radiation and contamination.

X8.3.3.2 If radiation is determined to be present, classify the response as to whether the source of the radiation (that is, the radioactive material) is contained and does not presently pose

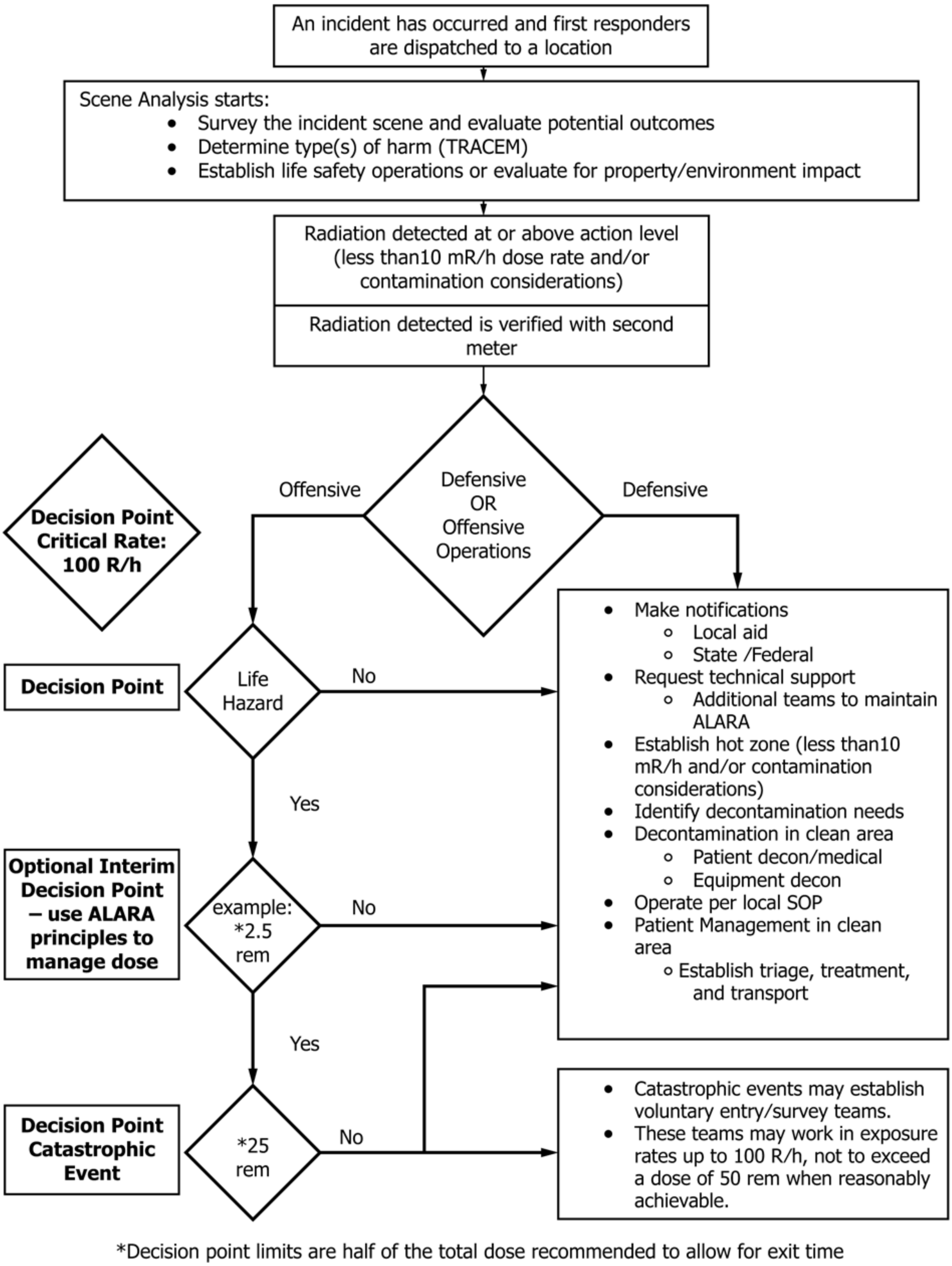

FIG. X8.1 Response Flowchart

an exposure or contamination risk to human health or the environment *or* the source of the radiation has been released or has the potential to be released and presents an exposure or contamination hazard.

X8.3.3.3 If radiation or contamination is determined to be present at the incident above normal background levels, verify measurements with a second instrument.

X8.3.3.4 Determine whether response operations can be managed in a defensive manner, or if offensive operations are also required. (Is life safety a concern? If yes, then offensive operations are required.)

(1) If defensive operations can be implemented establish the following:

(a) Notification details such as local, state, and federal law enforcement agencies including the FBI; local and state emergency management agencies and EOCs; Federal agencies such as Department of Homeland Security's Federal Emergency Management Agency, Department of Energy's Radiological Assistance Program, the Nuclear Regulatory Commission, the Environmental Protection Agency, and others as necessary.

(b) Request technical support and maintain ALARA principles.

(c) Radiation hot zone including exposure rate and surface contamination levels.

(d) Decontamination needs: decontaminate in a clean area and address issues associated with patient decontamination, medical needs, and equipment decontamination.

(e) Operations according to local SOPs.

(2) If offensive operations are required consider the following:

(a) Above the low exposure rate of less than or equal to 10 mR/h (0.1 mSv/h) at 1 m (3.3 ft), personnel are appropriately protected with radiation monitoring equipment and PPE.

(b) ALARA principles should be managed to the maximum extent possible. If life-saving is imperative, then proceed with operations. Responders must be informed and consent to the rescue operations.

(c) The high exposure rate decision point is not to exceed 100 R/h when reasonably achievable; above 100 R/h the IC should only commit informed, consenting responders to short duration life-saving activities.

(d) The maximum dose to emergency responders should not to exceed 50 rem when reasonably achievable.

X9. EMERGENCY RESPONSE CHECKLISTS FOR RADIOLOGICAL INCIDENTS

X9.1 The checklists that follow were designed for three levels of audiences:

X9.1.1 *Initial Responder*—The steps listed are designed for the initial responder, who may have minimal training and experience. The steps were designed to ensure the safety of responders and delineate actions to be taken if radioactive material is released or could be released presenting a hazard.

X9.1.2 *Trained Responder*—The steps listed are for the trained responder who has proper equipment and training.

X9.1.3 *Personnel Performing Exposure Rate or Dose Readings*—The steps listed are for anyone determining responder dose from exposure rate readings. They specify actions associated with radiological readings and precautions to be taken for the safety of all involved with the incident.

X9.2 The checklists are designed for use by emergency responders during unplanned radiological events. The purpose of the checklists is to ensure safety for the emergency responder and provide response guidance.

(1) Initial Responder

Initial Response and Assessment

- ☐ Identify wind direction and remain uphill and upwind
- ☐ Attempt to identify hazard(s) and location(s)
  - Markings, labels, and placards
  - Signs and symptoms of victims
  - Interviews of witnesses
  - Shipping documents
  - Instrument readings and/or alarms (Always confirm initial readings with a second survey instrument)
  - Shielding material (lead, plastic, special container, etc.)
  - Intelligence information
- ☐ Perform an Initial Hazard Assessment, using the information above
- ☐ Determine if the event is accidental or intentional
- ☐ Determine the background radiological exposure rate (average), if personnel have the proper equipment and training
- ☐ Remove victims or ask victims to move to an area of safety or security
- ☐ Request specialized resources and subject matter experts (State Radiation Control, EOD, SWAT, medical, etc.)

Safety, Equipment, and Scene Considerations

The following should be considered prior to committing personnel:

- ☐ Obtain proper equipment
  - ☐ Radiological survey instruments must be able to display and measure both exposure rates and contamination levels
- ☐ Obtain dosimeters for hot zone workers
- ☐ Implement standard personnel safety measures: ALARA (As Low As Reasonably Achievable) through use of time, distance, and shielding
- ☐ Appoint IC to implement command and control, manage the operations area, and direct resources
- ☐ Manage contact with victims to avoid cross-contamination
- ☐ Be aware of possible multi-hazard releases (explosives, chemicals, etc.)

☐ Establish scene security
☐ Establish crime scene preservation
☐ Determine the need for protective actions (shelter-in-place or evacuation)
☐ Maintain SECONDARY DEVICE SITUATIONAL AWARENESS

Command
☐ Establish unified command
☐ Assign a safety officer
☐ Assign ingress/egress routes
☐ Assign a staging area for responding resources
☐ Consider life safety and victim management concerns
☐ Provide briefings for hot zone personnel (entry teams)
☐ Ensure an adequate number of security personnel are assigned to provide scene security and force protection

Establishing Perimeters
Hot Zone
☐ Define a safety perimeter for initial containment that is less than or equal to 10 mR/h at 1 m (3.3 ft) and where contamination levels are at a minimum (for example, hot line)
☐ Determine an approved radiological dose limit and high-exposure rate. *The recommended maximum responder dose should not exceed 50 rem, with a high exposure rate not to exceed 100 R/h* when reasonably achievable.

Other Perimeters
☐ Determine the size of perimeters outside the hot zone. These may include the warm zone and cold zone. These perimeters should be larger than the hot zone and secured to keep uncontaminated individuals (responders and civilians) out. The perimeter should be large enough to allow emergency responders room to work and provide a level of safety to those beyond the perimeter.

Technical Considerations
☐ Determine the level and type of PPE needed (mission specific)
☐ Define intermediate zones based on local SOPs (for example, warm, cold, and decontamination corridor)
☐ Conduct a site assessment survey
☐ Map the scene and document radiation exposure levels in the inner and outer perimeters
☐ Conduct a security sweep for secondary devices or other hazards
☐ Conduct an outer perimeter sweep for missed materials or other hazards
☐ Determine the level and type of decontamination needed

(2) Trained Responder

Prior to committing personnel for an operational response, consider the following:

Life Safety Operations and Victim Management
☐ Life safety operations should be limited to: rescue, reconnaissance/device location, and fire suppression
☐ Obtain an estimated number of victims and type of injuries
☐ Ensure victims are triaged for treatment and decontaminated as needed
☐ Remove non-ambulatory victims from the hot zone for decontamination and treatment as appropriate
☐ Do not delay life-saving medical care for decontamination; attempt to remove as much contamination as possible, if time and the victim's condition permit

Personnel Protective Equipment (PPE)
☐ Determine the level and type of protective gear needed for the mission

Decontamination
☐ Establish decontamination locations in areas where background radiation is at a minimum to allow for effective surveying of potentially contaminated personnel
☐ Establish decontamination stations with radiological survey instruments (monitoring)
☐ Establish an emergency decontamination corridor
☐ Ensure monitoring is conducted to determine or verify the presence of contamination

Radiological Monitoring of Personnel
☐ Assign qualified personnel to set-up and use a personnel radiation monitoring program to track the dose of emergency responders

Medical Monitoring of Personnel
☐ Assign medical triage and pick-up locations

Equipment
☐ Determine what is available and which should be deployed
☐ Perform radiation monitoring and recording for on scene personnel
☐ Document dosimeter readings of personnel assigned to work in the radiological area

Scene Documentation
☐ Document initial scene assessment on forms approved by the IC
☐ Document and retain victim and witness statements
☐ Retain initial scene assessment for IAP

Hot Zone Entry
☐ Establish an emergency decontamination corridor
☐ Establish a functioning decontamination line and brief location(s) to all personnel
☐ Don specific PPE as authorized by the IC

☐ Ensure that entry personnel have radiation detection equipment prior to operations (minimum of one per entry team)
☐ Ensure entry team members have a dosimeter (each team member should be equipped if appropriate dosimetry is available)
☐ Perform all operational and safety checks prior to entry
☐ Receive authorization from the IC prior to making entry
☐ Ensure an appropriate number of rescue personnel are suited, ready, and standing by in the event they are required to make entry to perform a downed entry team rescue

Assemble a survey team to conduct a technical assessment
☐ Brief all members of the entry teams on missions, safety considerations, emergency decontamination, and egress locations
☐ Ensure the hazards, risks, and mission are clearly defined
☐ Brief the communications plan
☐ Brief the safety plan
☐ Brief the decontamination plan

(3) Personnel Performing Exposure Rate or Dose Readings

Key Decision Point: The high exposure rate decision point is recommended not to exceed 100 R/h when reasonably achievable; above 100 R/h the IC should commit only informed consenting responders to short duration life-saving activities. Individual responder dose should not exceed 50 rem.
Note: Radiation exposure rate readings in this range should not prohibit emergency operations, confirm operations with the IC.
☐ Confirm initial readings with a second survey instrument, (if possible, use another instrument type)
☐ Determine source location, if possible
☐ Document radiological measurements in a systematic manner to create a map of the scene
☐ Transmit hazard information and the scene map to the IC
☐ Determine if the source is from a legitimate user or licensee
☐ Determine the physical state of the source (solid, liquid, or gas)
☐ Identify victims
☐ Make notifications in accordance with procedures

For operations personnel handling the radiological incident:
Establish Hot Zone (only life-saving operations justify work in the hot zone)
☐ Confirm initial readings with a second survey instrument, (if possible, use another instrument type)
☐ Notify the IC of the radiation exposure levels detected
☐ Establish the hot line boundary (less than or equal to 10 mR/h), mark line with cones, tape, paint or other marking device
☐ Determine if the event is accidental or intentional
☐ Approve and conduct life-saving operations in the hot zone
☐ Confirm hot line boundary with a second survey instrument
☐ If a fire is involved, determine if a radioactive material was involved
☐ Determine and verify source location, if possible
☐ Determine if there are viable victims
☐ Request technical support

Hot Zone Entry
☐ Request permission to continue operations in the hot zone, based on approved mission objectives
If authorization is DENIED:
☐ Leave the hot zone and proceed to designated decontamination area
☐ Maintain respiratory protection until clear of the hot zone
☐ Report for medical monitoring
☐ Complete and turn in exposure reports and radiation exposure logs
If authorization is GRANTED:
☐ Continue operations; notification is required if based on local SOPs and guidance from IC; for example a dose alarm decision might be set at 12 rem

Exposure rate or dose reaches interim decision points:
☐ Notify the IC
☐ Request authorization to continue operations in the hot zone, based on mission objectives
If authorization is DENIED:
☐ Leave the hot zone and proceed to designated decontamination area
☐ Maintain respiratory protection
☐ Report for medical monitoring
☐ Complete and turn-in exposure reports and radiation exposure logs
If authorization is GRANTED:
☐ Continue operations; notification is required if based on local SOPs and guidance from IC

If exposure rate of greater than 100 R/h is observed:
☐ Notify the IC of the radiation exposure rate observed
☐ If viable victims are located beyond this reading, provide the location to the IC
☐ Establish a high exposure rate line. Mark the line with cones, tape, paint or other marking device
☐ Do not proceed past the high exposure rate line without permission from the IC

Reaching Maximum recommended dose 50 rem
☐ Lifesaving or protection of large populations; only by volunteers who fully understand the risks involved and mission requirements
☐ Notify the IC
☐ Request authorization to continue operations in the hot zone, based on mission objectives
☐ Report for medical monitoring
☐ Complete and turn-in exposure reports and radiation exposure logs

Exceeding Maximum Allowable Dose 50 rem, Catastrophic Event

- ☐ Life-saving operations permitted only with authorization of the IC, after a risk benefit analysis
- ☐ Lifesaving or protection of large populations; only by volunteers who fully understand the risks involved and mission requirements
- ☐ Exposure rates and responder stay times must be closely monitored
- ☐ Report for medical monitoring
- ☐ Complete and turn-in exposure reports and radiation exposure logs

X10. RADIATION UNITS, CONVERSIONS, AND ABBREVIATIONS

X10.1 *Radiation Measurement Units*:

	Common Units	SI Units
Radioactivity	Curie (Ci)	Becquerel (Bq)
Absorbed dose	rad	Gray (Gy)
Dose equivalent	rem	Sievert (Sv)
Exposure	Roentgen (R)	Coulomb/Kilogram (C/kg)

X10.2 *Conventional/SI Unit Conversions*:

1 Curie = 3.7×10^{10} disintegrations/s	1 Becquerel = 1 disintegration/s
1 rad	0.01 gray (Gy)
1 rem	0.01 sieverts (Sv)
1 roentgen	0.000258 Coulomb/Kilogram (C/kg)
1 gray	100 rad
1 sievert	100 rem
1 Coulomb/Kilogram (C/kg)	3876 roentgens

X10.3 *Abbreviations for Radiation Measurements*:

X10.3.1 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. The table below shows the prefixes for radiation measurement and their associated numeric notations.

Prefix	Equal to	How Much Is That?	Abbreviation	Example
atto-	1×10^{-18}	0.000000000000000001	a	aCi
femto-	1×10^{-15}	0.000000000000001	f	fCi
pico-	1×10^{-12}	0.000000000001	p	pCi
nano-	1×10^{-9}	0.000000001	n	nCi
micro-	1×10^{-6}	0.000001	μ or u	μCi or uCi
milli-	1×10^{-3}	0.001	m	mCi
centi-	1×10^{-2}	0.01	c	cSv

X10.3.2 When the amount to be measured is 1000 (that is, 1×10^3) or higher, prefixes are attached to the unit of measure to shorten very large numbers (also scientific notation). The table below shows the prefixes used in radiation measurement and their associated numeric notations.

Prefix	Equal to	How Much Is That?	Abbreviation	Example
kilo-	1×10^{3}	1000	k	kCi
mega-	1×10^{6}	1 000 000	M	MCi
giga-	1×10^{9}	1 000 000 000	G	GBq
tera-	1×10^{12}	1 000 000 000 000	T	TBq
peta-	1×10^{15}	1 000 000 000 000 000	P	PBq
exa-	1×10^{18}	1 000 000 000 000 000 000	E	EBq

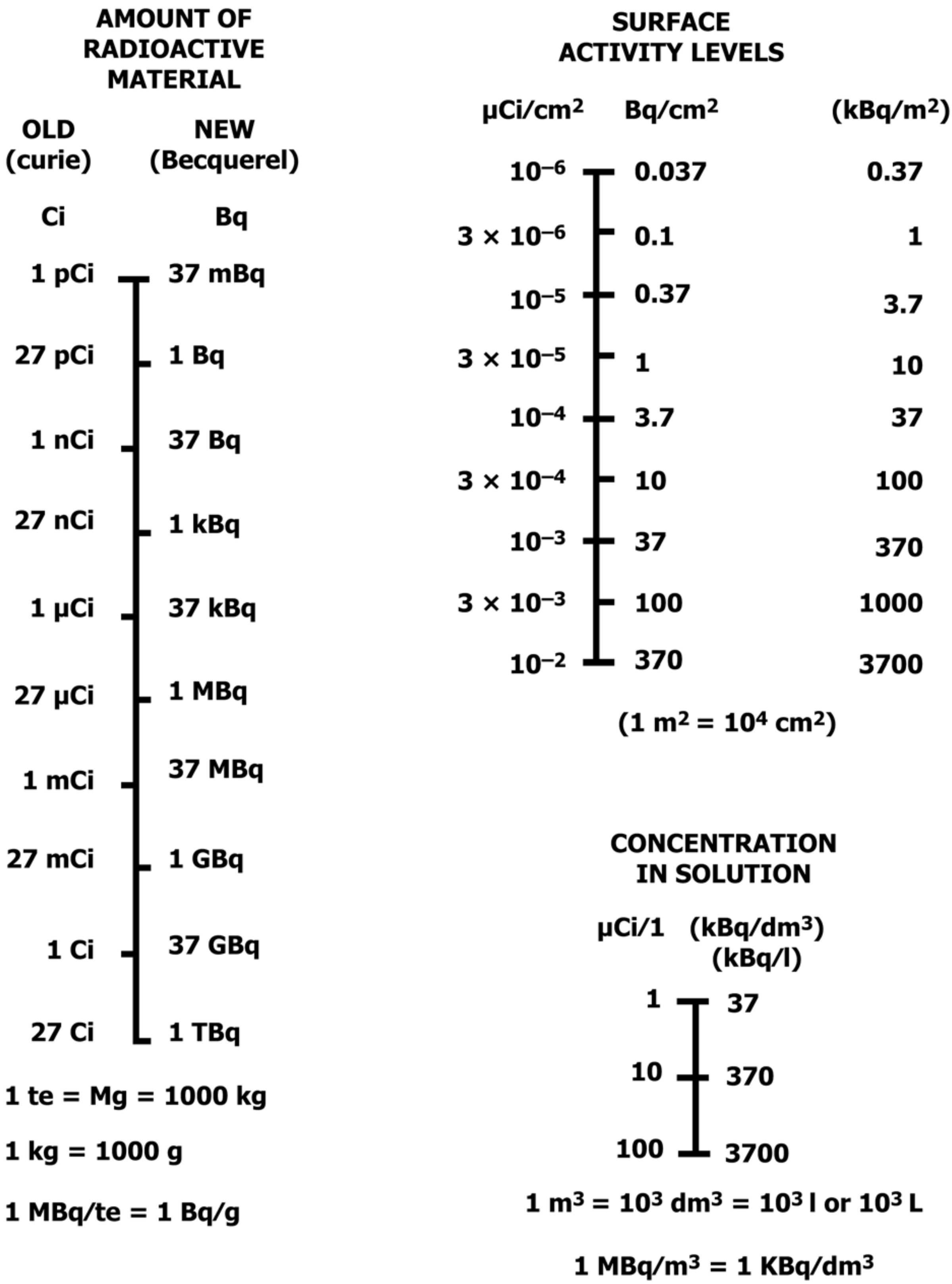

FIG. X10.1 Units and Conversions

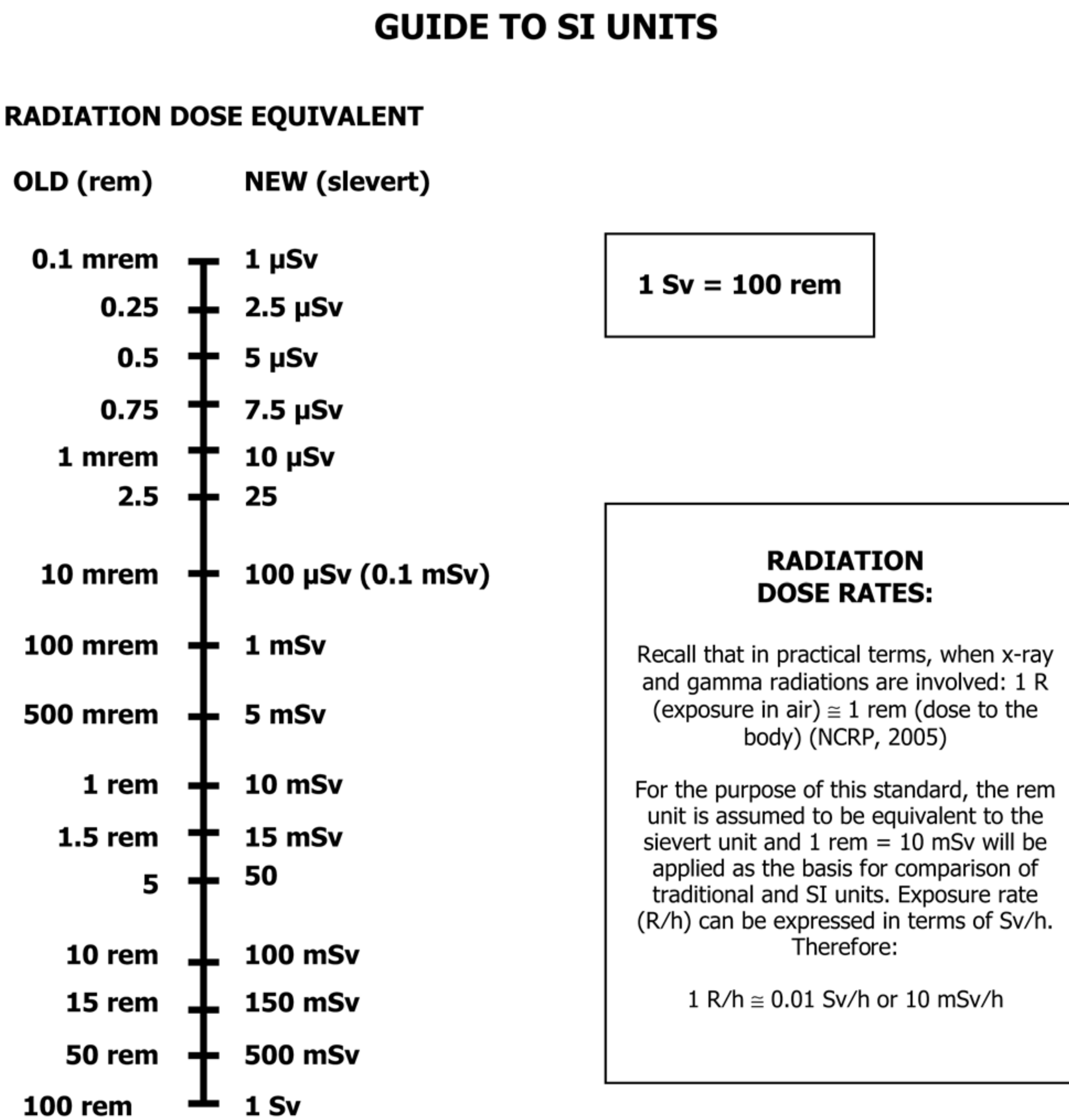

FIG. X10.2 Guide to SI Units