Quick Reference Guide:

Radiation Risk Information for Responders Following a Nuclear Detonation

December 2016

Quick Reference Guide

This document supports the "Planning Guidance for Response to a Nuclear Detonation" and was designed to provide responders with specific guidance and recommendations about the radiation risk associated with responding to an improvised nuclear device (IND) event, in order for them to protect themselves from the IND effects. It is intended to be part of preparation training with the "Health and Safety Planning Guide For Planners and Supervisors For Protecting First Responders Following A Nuclear Detonation".

This provides basic information responders will need for the first 24 -72 hours after an extreme event -- a nuclear detonation. These guidelines are not designed to apply to other, less extreme, radiological events. Specific information/training should be sought for those.

Some of this guidance will be counterintuitive to those trained in emergency response; however, it is critical that responders remain as safe and healthy as possible, not only for their own safety, but also to remain available for the ongoing mission of saving lives. Responders involved in an IND event need to be prepared to see numerous victims with serious traumatic injuries and illness including: severe burns, blindness, deafness, amputations, radiation sickness, etc.

What would a nuclear detonation be like and what can you expect?

- The **Nuclear Flash** would come in the form of an intense burst of light and extreme heat potentially creating a firestorm. Injuries: flash burns, flame burns, flash blindness, and retina burns.
- **Prompt Radiation** would be delivered, resulting in high radiation doses close to the detonation. Injuries: possibility of immediate or delayed (weeks or months) illness or death.
- The **Nuclear Blast** would include an initial fireball, overpressure wave, and extreme high winds. Injuries: crushing, fractures, lacerations, rupture of the viscera, and pulmonary hemorrhage and edema. All of this would take place in mere moments.
- The **Mushroom Cloud/Fallout** radioactive material mixed with debris is carried up and spread by winds for miles. Delayed Injuries: radiation exposures, potentially lethal exposures closer to the detonation.
- The **Electromagnetic Pulse (EMP)** produces a high-voltage surge that poses no direct health threat, but may damage electronic equipment two to five miles from ground zero and disrupt communications.

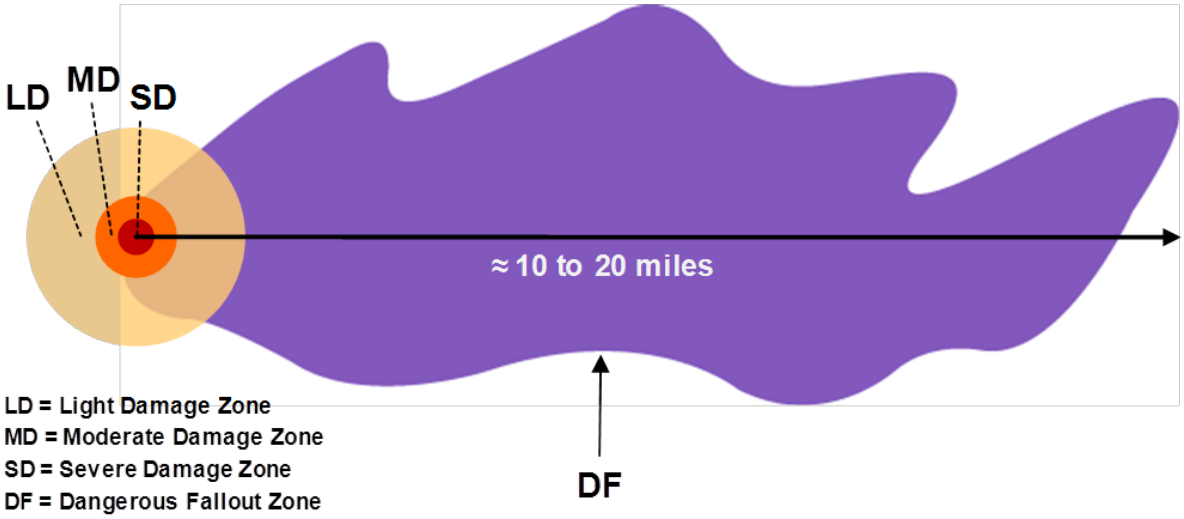
Zoned Response

There will be two different kinds of zones: Damage & Fallout zones
Response organizations will use these terms to establish official zones
*(These distance **estimates** are for a 10 KT IND, ground burst)*

Severe Damage – **0 to 0.5 mi**: Buildings completely destroyed, **radiation is too high to enter** for 72 hours, survivors unlikely

Moderate Damage – **0.5 to 1 mi**: Significant building damage, rubble, downed power lines, overturned vehicles, limited visibility for the first hour or more due to dust and smoke, serious injuries, **best lifesaving opportunities**.

Light Damage – **1 to 3 mi**: Windows mostly broken, injuries not expected to be life-threatening



Fallout zones change with time. As the fallout is spread by wind the area expands. After the initial distribution, the zones shrink as the radioactivity decays.

Dangerous Fallout zone – **up to 20 mi** from ground zero: Radioactive dust from the explosion create radiation levels exceeding **10 R/hr** (see table)(*0.1 Gy/h*), not limited to damage zones, **actions taken** here must be **justified**, planned and always kept As Low As Reasonably Achievable (ALARA); **time-sensitive**, mission-critical activities such as rescuing identified injured survivors. Advise other survivors to shelter in place.

Elevated radiation area – **up to several hundreds of miles**: from **0.01 R/hr to 10 R/hr (***0.0001 to 0.1Gy/h***)**, potentially hazardous, and cumulative radiation exposure should be monitored.

Key Points for Zoned Response

Most people in the LD zone will survive on their own, but critical injuries may still exist.

MD zone outside of the DF zone - Area with the **most survivable victims** and therefore the maximum rescue potential. Rescue efforts should be concentrated in this area.

Many people in the MD zone will survive only if they are rescued and treated.

Most people in the SD zone will not survive, even if they can be rescued.

The **DF zone** is extremely hazardous and **should not be entered without justification**.

Responders should approach the area from upwind, outside of the fallout zones.

Responders should assess the surroundings to determine if rescue measures are immediately needed or can wait until radiation levels can be accurately determined and the responders are formally dispatched through the Incident Command System.

Responders should not rush into the most damaged areas, without a thorough hazard and mission assessment.

What happens to the body when exposed to radiation?

There are two ways to be affected by radiation; **exposure** and **contamination** (see protective gear)
There are two types of **effects** on the body; acute and long-term.

1. **Acute**: This is when the body gets a large dose of radiation quickly; symptoms can manifest quickly, minutes to hours. See the table below for the onset times for initial affects.

Acute Radiation Syndrome (Radiation Sickness) *

Feature or Illness	Effects of Whole Body Absorbed Dose from external radiation or internal absorption, by dose range in rad/*Gy*				
	0-100 (*0-1*)	100-200 (*1-2*)	200-600 (*2-6*)	600-800 (*6-8*)	>800 (*>8*)
Nausea/Vomiting	None[a] (see note)	5-50%	50-100%	75-100%	90-100%
Time of Onset after Exposure		3-6 hr	2-4 hr	1-2 hr	<1 hr to minutes
Duration		<24 hr	<24 hr	<48 hr	<48 hr
Lymphocyte Count (blood)	Unaffected	Minimally Decreased	<1,000 at 24 hr	<500 at 24 hr	Decreases within hours
Central Nervous System Function (brain & nerves)	No Impairment	No Impairment	Cognitive impairment for 6-20 hr	Cognitive impairment for > 20 hr	Rapid incapacitation
Death	None	Minimal	Low with aggressive therapy <5 to 50%[b]	High	Very High

*Prompt health effects from whole-body absorbed doses received within a few hours.

a. A small number of exposed individuals may experience symptoms such as nausea and vomiting at doses between 50 and 100 rad (0.5 and 1 Gy).

b. The LD 50/60 or the lethal dose with NO medical intervention to 50% of the population after 60 days is between 320 and 450 rad (3.2 - 4.5 Gy).

2. **Long-term**: There is an increased risk of getting cancer later in life after a radiation exposure. Any risk of life-shortening effects from radiation is proportional to the dose. Most cancers are not likely to occur until several decades after exposure; although leukemia has a shorter latency period (<5 yr), NCRP Commentary No.19 Key Elements of Preparing for Nuclear and Radiological Terrorism (2005).

Fatal Cancer

	Effects of Whole Body Absorbed Dose from external radiation or internal absorption, by dose range in rad (*Gy*)		
	0-100 (*0-1*)	100-200 (*1-2*)	200-600 (*2-6*)
Percentage of Increased Lifetime Risk[1]	1 rad = 0.06% 10 rad = 0.6% 50 rad = 3% 100 rad = 8%	100 rad = 8% 150 rad = 9% 200 rad = 16%	200 rad = 16% 300 rad = 24% 600 rad = >40%

[1] Derived from EPA Radiogenic Cancer Risk Models and Projections for the U.S. Population, April 2011 and from NCRP Commentary 19.

Incidents involving radiation or radioactive material usually will require responders to be aware of the potential for health effects associated with various levels of radiation exposure. Any whole-body radiation dose can increase a person's lifetime risk of fatal cancer. As the dose increases, the risks also increase. High radiation doses (i.e., >100 rad (1Gy)) can be potentially life-threatening, although the risk of acute death from radiation can be mitigated through prompt medical treatment. Without proper medical assistance 50% of people with radiation doses of ~400 rem (rad or 4 Gy) or higher will most likely die in 60 days.

State and local jurisdictions may have their own guidance regarding decision dose limits. Responders should abide by jurisdictional limits until the IC system is in place and new limits have been established.

"RULES OF THUMB" FOR RESPONDERS

At first sign of a nuclear explosion	Shelter-in-place at the first sign of an intense flash of light and stay sheltered for at least one hour to let the initial dust settle. Cover ears against sound that will follow the visual blast.
Don't rush in	Determine radiation levels first, wear appropriate PPE, define the mission
Stay aware of wind and weather	Always approach potential fallout zones from upwind direction
Radiation Dose	❖ The annual occupational dose limit for ionizing radiation is 5 rem (rad or *0.05 Sv*) *This limit would likely be exceeded in an IND emergency* ❖ **Keep exposures to a minimum, for the health and safety of responders** ❖ Normal guideline for lifesaving or protection of large populations, 25 rem (rad or *0.25 Sv*) ❖ Catastrophic event, such as an IND incident, may warrant > 25 rem (rad or 0.*25 Sv*) for lifesaving.
Exposure	❖ Responders who are reasonably expected to exceed more than 25% of the occupational dose limit, should be appropriately monitored. ❖ Ensure responders have been adequately informed of and have an adequate understanding of the risks, including of short- and long-term effects, they may experience during missions, and are trained, to the extent feasible, on actions to be taken. ❖ Each responder must make an informed decision as to how much radiation risk they are willing to accept to save lives.
Area for maximizing rescue potential	The portion of the MD zone falling outside of the DF zone offers the best potential for rescuing the most survivable victims.
Recognizing Fallout Particles	Fine, sand-sized grains. However, lack of apparent fallout does not suggest lack of radiation. Continued radiation monitoring is required.
Fallout decays rapidly	7-10 Rule: For every sevenfold increase in time after detonation, there is a tenfold decrease in the radiation rate. So, after seven hours the radiation rate is only 10% of the original and after 49 hours (7 x 7 = 49) it is 1%.
Decision Dose or Turn-back Dose	When approaching or surveying the scene, the 10 R/h (*0.1 Gy/h*) point normally indicates that workers should return to a safe area, unless they are undertaking a sufficiently justified mission to validate the exposure.
Acute Radiation Syndrome (ARS)	Nausea, vomiting or diarrhea indicates exposure of 100 rad (*1 Gy*) or more. Exit radiation area immediately and seek medical care.
Decontamination*	Remove all outer clothing and footwear. Shower if possible, or wipe skin and hair with moist towelettes.

***** For Medical Responders: Provide life-saving medical care before decontamination.

Do not forget -- all of the other hazards that go with a catastrophic event will still exist.

CONSIDERATIONS FOR SELF-PROTECTION AGAINST RADIOACTIVE CONTAMINATION

Reminders: ***These items will not protect you from radiation exposure, only contamination.*** *Radiation exposure does not necessarily mean someone is contaminated with radioactive particles.*

Wear Personal Protective Gear appropriate to you role and hazards you may encounter.

Headgear	Coated hood, or a helmet. Hard hat recommended due to falling debris.
Eyewear	Full-face respirator protects eyes or chemical goggles with a half-face respirator.
Ear protection	Hood or helmet to cover ear canal and prevent entry of dusts. Alternative: Hearing protection
Respirator	Self-contained breathing apparatus (SCBA) when dust levels are extremely heavy (i.e., obscure vision at 200 feet), if available, use NIOSH-certified. Full-face air-purifying respirator (APR) with P-100 filter at a minimum. If available, use a pre-filter that is attached over the outer face of the cartridge and change these whenever breathing becomes more difficult and every time the elevated radiation zone is exited. The pre-filter must be manufacturer-approved for use with the specific respirator and cartridge assembly worn. CAUTION: If not experienced in changing filter/cartridges in a contaminated environment, users should not attempt to change in if not in the clean zone.
Torso	Firefighters: Turnout gear All others: Coated coveralls for entry into contamination zones and coveralls for work in zones with <1 R/hr (*0.01 Gy/h*).
Gloves	Nitrile disposable or neoprene, cotton liner optional
Footwear	Firefighters: Firefighter footwear All others: Latex booties over sturdy footwear or neoprene boots
Radiation Dosimeter	If available, radiation dosimeters can help you determine how much you have been exposed to and when you need to leave the radiation area. Remember to return them for reading and use by other responders. When available, it is recommendable that electronic personal dosimeters are used with alarm dose and alarm dose rate capabilities.

After hazards have been determined, PPE requirements may be increased or relaxed, upon approval of the Incident Commander or Site Safety Officer

For further information see “Planning Guidance for Response to a Nuclear Detonation and the Health and Safety Planning Guide For Planners, Safety Officers and Supervisors For Protecting Responders Following A Nuclear Detonation”.