Development of the Updated Environmental Protection Agency Manual of Protective Action Guides (PAGS) and Protective Actions for Nuclear Incidents - 8298

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ABSTRACT

As a student intern with the United States Environmental Protection Agency (EPA) Headquarters, the author was trained in the National Response Plan (NRP) and assisted in the editing of the new (unpublished) EPA Protective Action Guides (PAGs) [1] which has been revised in light of the perceived post 9/11 potential for "Dirty Bomb" and "Improvised Nuclear Device" attacks on civilian areas. Technical aspects and the public policy aspects of developing the new guides are discussed. Early Phase initial responses discussed include: Notification of state and/or local authorities, immediate evacuation/sheltering prior to release information or measurements, monitoring of releases and exposure rate measurements, estimation of dose consequences, implementation of protective actions in other areas.

The new PAG clarifies the use of 1992 PAGs [2] for incidents other than nuclear power plant accidents, lowers projected thyroid dose for potassium iodine (KI), provides drinking water guidance, includes guidance for long-term site restoration, and updates dosimetry from ICRP 26 to ICRP 60

INTRODUCTION

A Protective Action Guide (PAG) is a valu**e** against which to compare the projected dose to a defined individual from a release of radioactive material at which a specific protective action to reduce or avoid that dose is warranted and a projected dose is a dose that can be averted by protective actions.

EPA has been delegated the responsibility for providing guidance to other federal agencies on radiation exposure limits. 1982, FEMA regulations governing radiological emergency planning and preparedness required EPA to (1) establish the PAGs, (2) prepare guidance on implementing the PAGs, and (3) develop and promulgate guidance to state and local governments on the preparation of emergency response plans. The most recent version of the PAG Manual was issued in 1992 [2]. Like earlier versions, the guidance was very Nuclear Power Plant (NPP) focused. At the time the guidance was written, EPA and others in the emergency response community believed that if PAGs worked for nuclear power plant emergencies, then they would be effective for all nuclear or radiological incidents.

The EPA is not in charge of telling anyone how to clean up after these incidents. The PAGs are general guidance for state authorities, local authorities, and the government agency that has jurisdiction for each particular radiological event. However, if no agency claims responsibility, the EPA can assume responsibility for the clean-up of radiological sites.

The PAGs are used by local and state government officials to determine how to proceed after a radiological event has been detected. The PAGs are well known and supported by technical societies such as the Health Physics Society [3].

Additions to The Revised PAGs Manual

There are many additions to the revised PAGs manual that go beyond the nuclear power plant (NPP) issues that were discussed in the earlier versions of the manual and additionally in the PAG MANUAL WORKSHOP developed by the EPA [4].

Radiological Dispersion Devices

Information on Radiological Dispersion Devices (RDD) was added to the manual. A radiological dispersion device is commonly known as a “dirty bomb.” A dirty bomb is an explosive device laced with radioactive material, but it does not have to be explosively detonated. Other methods of dispersal may be used such as aerosols, sprays, or liquids. There is likely no warning before these devices are set off. Once they are set off, they release a plume of radioactivity into the air that will cover a relatively small area such as several city blocks. As soon as the device is set off, the individuals and structures in the affected area will likely be contaminated and the affected area should be contained for proper decontamination as soon as possible.

To illustrate the importance of including the updated information on RDDs, the EPA generated graphic below (Fig. 1) demonstrates the differences in public exposure time for NPP and RDD events. It is apparent that the public exposure times vary significantly for these events.

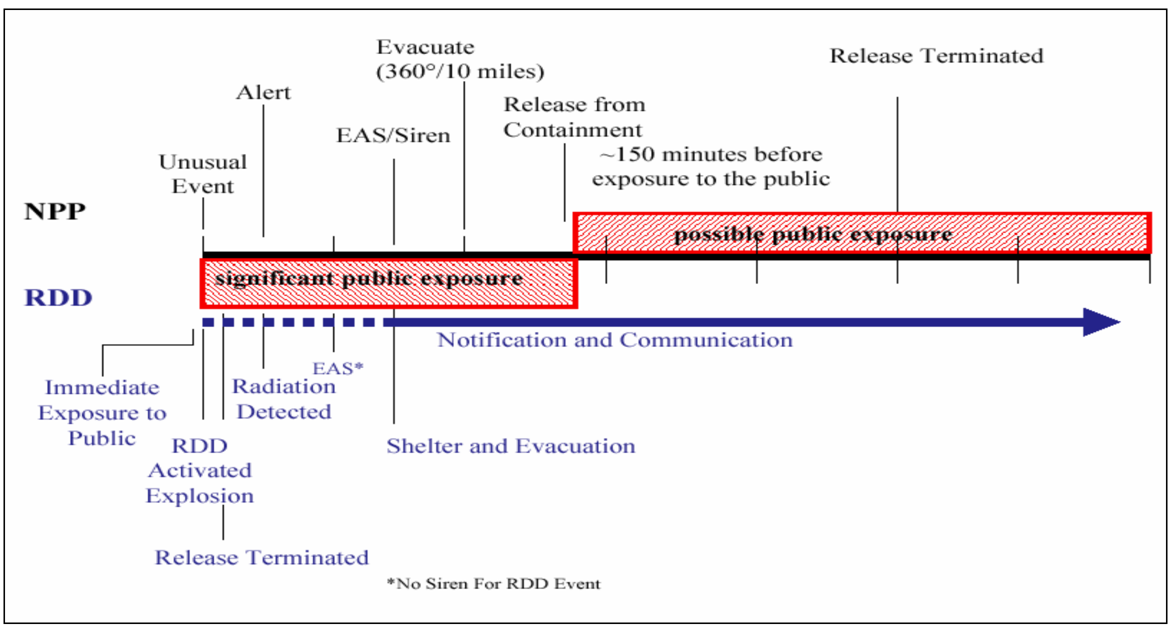

Fig 1. Timeline for NPP and RDD events.

Improvised Nuclear Devices

Another addition of importance is guidance for Improvised Nuclear Devices (INDs). INDs can be a stolen nuclear weapon from an acknowledged nuclear nation or a homemade nuclear device created by either a governmental (non-acknowledged nuclear power) or non-governmental group. Initially, it might be difficult for the public to distinguish a small IND detonation from an ordinary explosive device. The larger IND explosions should be easier to recognize as a nuclear device. Although the initial response to an IND event will be similar to the response to an ordinary explosion the subsequent actions will be tailored to the radiological effects.

Radiological Terrorism

Due to the events of 9/11, the threat of radiological terrorism is a new topic discussed in the manual. The Department of Homeland Security (DHS) inspected the PAG Manual for application to RDDs or INDs and identified the need for Late Phase, or recovery, guidance. The PAGs were applied to IND events by (1) scope and scale, (2) priority on lifesaving and avoidance of acute effects, (3) short response timeframe, and (4) unique fallout decay curve.

It is recognized that the response to both RDD and IND devices is unique and will be very different than the response to a nuclear power plant incident. Each response should be tailored to the affected population, area of concern, and isotopes of concern.

Other Additions and Changes

The protective action for a thyroid dose was lowered from the adult dose of 25 rem (250 mSv) to the child dose of 5 rem (50 mSv). This is consistent with the Federal Drug Administration (FDA) guidance issued in 2001 based on data obtained from Chernobyl. Setting one overall limit simplifies the protective action and makes evacuation the probable response whenever radioactive iodine is released.

The earlier Manual included a promise that PAGs for drinking water would be included in the next release of the Manual. These promised drinking water guidelines of 0.5 rem (5 mSv) first year Committed Effective Dose Equivalent (CEDE) are contained in the updated Manual. It is important to note that this is a CEDE and not a whole body dose because the only pathway for contamination being considered is ingestion. This applies to drinking water only and is not intended to set the acceptable level of contamination in all water sources.

The guidance for food was updated to the FDA 1998 guidance from the FDA 1982 guidance used previously. That guidance is the most limiting of 0.5 rem (5 mSv) whole body or 5 rem (50 mSv) to most exposed organ or tissue. Isotope specific uptake and guidance related to animals and pets are not addressed.

The dose guidelines are now based on the advice of the International Commission of Radiological Protection (ICRP) Publication 60+ instead of the previous used ICRP 26.

Another important addition is the information on long-term site restoration guidelines that are included in the new PAGs Manual. The goal is return the incident site to as close to the previous normal as possible.

Phases Of Pags

The PAGs Manual is divided into guidance for 3 separate phases which may sometimes overlap. These phases are called the Early Phase, the Intermediate Phase, and the Late Phase. The timeline for these phases is shown in Fig 2.

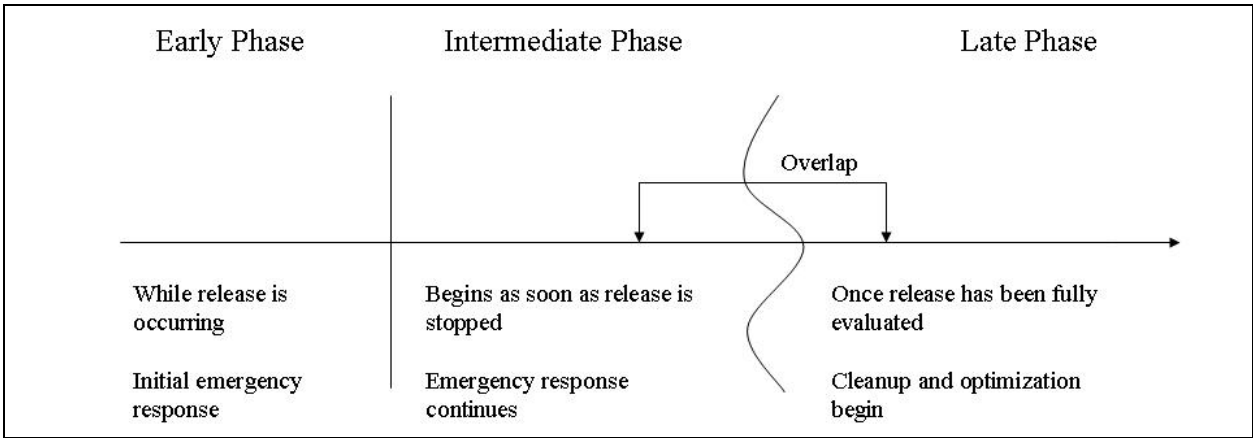

Fig 2. Timeline for response phases.

Early Phase

The Early Phase occurs as soon as a radiological release begins and lasts until the time the release is stopped which can be from several hours to several days. During this time, not much data about the radionuclides of concern or the scope of the incident are known. This stage's initial response involves:

- Notification of state and/or local authorities
- Immediate evacuation/sheltering (if necessary) prior to releasing information or measurements
- Monitoring of releases and exposure rate measurements
- Estimation of dose consequences
- Implementation of protective actions in other areas, if necessary

Exposure occurs by 2 main pathways during the Early Phase. It occurs by direct exposure and inhalation. Direct exposure to the skin occurs when material from the plume settles onto an individual or if an individual touches an object that has been contaminated. The other route of exposure is inhalation. Inhalation occurs when an individual is immersed in the radioactive plume and breathes in the radioactivity through the lungs. The main concern during the Early Phase is inhalation because the dose from inhalation is usually much greater than the dose from direct exposure.

During the Early Phase the primary protective actions are evacuation and/or sheltering. Both of these protective actions are unchanged from the original manual. For evacuation, avoiding pubic exposure is the primary objective. This is attained by removing people from all areas in the projected path of the radiation plume. Evacuation is an effective form of protective action if it occurs before the plume reaches the evacuation areas.

A less disruptive protective action against public exposure to radioactive materials is sheltering, also known as sheltering in place. Sheltering involves moving everyone inside nearby structures that serve to help reduce or eliminate the potential exposure from the inhalation pathway. For certain radionuclides, such as noble gases, where inhalation is the key exposure pathway, sheltering in a building that is sealed off from outside air is often the best action. Sheltering is also an effective response for RDDs that go off inside buildings, such as airport lobbies or shopping malls, where contact is the main form of dispersal. For all situations, the authorities have to weigh every situation carefully to decide the best course of action.

Intermediate Phase

The Intermediate Phase begins after the release of radioactivity is under control or has been stopped. The situation is better understood than it was during the Early Phase because there has been time to analyses the incident, the radioisotopes of concern, the wind conditions, and other related factors. It is also important to note that by this time Federal or other out-of-area assistants may be available to help local emergency workers to control the larger incidents. During this time, emergency actions will be taken and the protective actions will be the most restrictive because the responders have had time to better evaluate the incident. This stage often overlaps with the Early Phase as the controlled release is stopped and the Late Phase as the recovery/reclamation process is planned and the emergency response is completed.

The sequence of events for RDD and IND events during the Intermediate Phase is:

- Identify high dose rate areas
- Relocate population from high dose rate areas
- Allow return of evacuees to non-contaminated areas
- Establish relocation areas
- Establish procedures for reducing exposure of non-relocated population
- Perform detailed environmental monitoring
- Decontaminate essential facilities and routes
- Begin recovery activities

Some of these events may overlap at times, but this is a good guideline for actions during the intermediate phase.

The current draft of the PAG Manual includes the Dose Conversion Factors (DCF) and Derived Response Levels (DRL) for those radionuclides most likely to be released during a nuclear incident. These values will assist decision-makers in translating measurements of radionuclides given in Curies (Ci) to dose limits given in rem. The PAGs manual uses software called TurboFRMAC to perform all dose calculations. These dose calculations are used to identify the high dose areas for relocation purposes. Once the estimated doses are calculated, the response areas will be determined. Fig. 3 shows an example of a theoretical response areas chart.

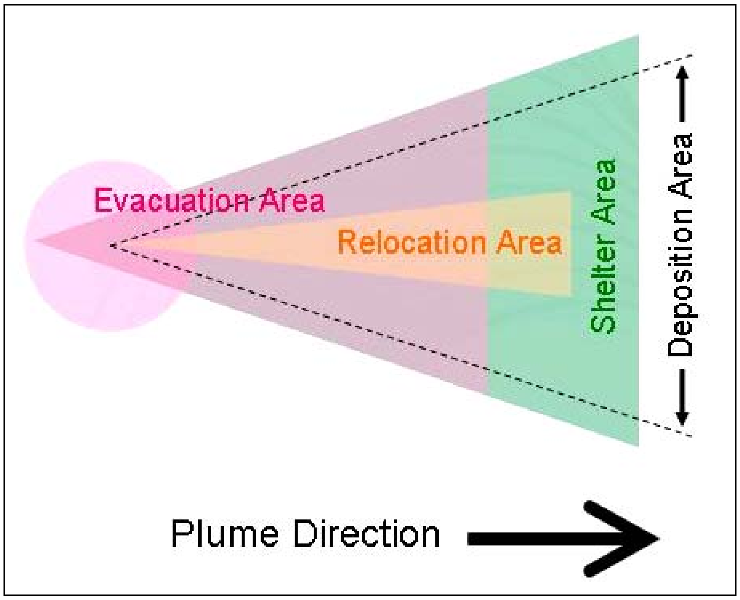

Fig.3 Response areas.

Once the expected dose rates have been determined, people residing in the relocation area will first be relocated to a predetermined safe area. Relocation occurs when the projected dose exceeds 2 rem per year. Relocation areas are completely evacuated and no one is permitted to live or work in these relocation areas. Next, people who were initially evacuated during the early phase are allowed to return to safe areas that were determined to not be contaminated and are not part of the relocation area. These people are allowed to resume normal living. During this time, dose reduction techniques will be used for the safety of non-relocated persons and the de-contamination of buildings and grounds begin.

The two primary pathways for the Intermediate Phase are whole body external dose resulting from deposited radioactivity and internal dose associated with the inhalation of radioactive particles. Doses from ingestion may need to be considered if food and water supplies are contaminated. Furthermore, in some cases, skin exposure to beta radiation may also present a significant risk, depending on which radionuclides were released. The general guidance for the Intermediate Phase is shown in Table I.

Table I. Table of Protective Action Guides for the Intermediate Phase.

Protective Action Recommendation	PAG Projected Dose	Comments
Relocate the general population	≥ 2 rem (20 mSv) First year	Beta dose to skin may be up to 50 times higher
Apply simple dose reduction techniques	< 2 rem (20 mSv) First year	Reduce doses to as low as practical levels
Longer term objectives	0.5 rem (5 mSv)	In any single year after the first
	≤ 5 rem (50 mSv)	Cumulative dose over 50 years

Note that overall dose is considered, not the dose from individual radionuclides. This means that the response is not specialized for hard to eliminate or easily decontaminated radionuclides.

Late Phase

The Late Phase involves long-term recovery and cleanup. It is often the longest stage, lasting from a year to several decades, and begins after the emergency response is completed and most of the data such as radionuclides of concern and extent of contamination is known. The goals of the Late Phase are as follows:

- Restoration of incident site to conditions as near as possible to pre-existing -creation of a "new normal"
- Remove contamination
- Eliminate access restrictions
- End food and water controls
- Return population to homes and jobs
- Cleanup and recovery

It is usually impractical if not impossible to completely return an incident site to pre-incident conditions. The goal is to return the site to as close to pre-existing conditions as possible. The difficult part of this task is ensuring that the site is considered normal and safe by the public. This is accomplished by removing the contamination. All contaminated materials, soil, etc. often need to be removed and buildings and permanent structures must be thoroughly decontaminated until the residual contamination is well below agreed upon clean criteria. After the site is clean, the access restrictions will be lifted and people can reenter the site. Usually cleanup is a long process and people are allowed reentry, meaning they are allowed to enter the area for short periods of time for work related purposes only, but are not allowed to reside in the area. It is also important in ensure that the drinking water and food are well above PAG levels and normal use will not contribute to contaminating the public. Next, normal living resumes as the public is allowed to return to the area to live and work. Long-term clean up and recovery may still occur for many years to return some areas to desired pre-incident conditions.

The Department of Homeland Security (DHS) took the lead for developing these Late Phase PAGs. The DHS document will be approved in parallel with the EPA PAGs Manual. It was determined that optimal numbers for declaring a site clean were unattainable and needed to be specific for each situation. Therefore no specific numbers are suggested in the late phase PAGs, but it is desired that the benefit of a cleanup procedure be weighed against the cost and consequences of these actions. This concept is called optimization.

Optimization is based on the general principle that exposure to radiation should be controlled so as to achieve the lowest level reasonably attainable. The optimization principle is applied on a case-by-case basis, and numerical radiation criteria for cleanup depend on the specific circumstances of each incident. The PAG Manual provides several "benchmark" criteria that may be considered by a site recovery work group, including those used by the Superfund remedial site cleanup program and the NRC/Agreement States decommissioning programs.

CONCLUSION

The EPA PAGs Manual is useful for responding to radiological incidents. It is not as comprehensive as some might wish but it provides an authoritative source of basic guidance to local authorities that may need to respond to radiological events. The manual helps by offering guidance with the initial response as well as the recovery and cleanup processes. Once the new Manual is released it will be much more relevant than the current manual since, in addition to NPPs, it will also included information on RDDs, INDs, and drinking water. Currently the Manual is undergoing internal review. It is expected to be open for public comment in 2008. The EPA's website has a webpage [5] that contains more information about PAGs and the Manuals progress.

REFERENCES

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