Lesson Overview

This lesson presents basic Radiological Emergency Preparedness (REP) concepts.

Lesson Objectives

At the completion of this lesson, you will be able to:

- Define the four Emergency Classification Levels (ECLs).
- Define Protective Action Guides (PAGs) and select examples of protective actions.
- Define Emergency Planning Zone.

REP and ECLs

FEMA, which has been incorporated into the U.S. Department of Homeland Security, is the lead Federal agency for planning and preparedness for all types of peacetime radiological emergencies. In this course, we'll focus on incidents at nuclear facilities.

Responsibility for planning and preparedness activities within and outside the nuclear power plant boundaries is divided between the U.S. Nuclear Regulatory Commission (NRC) and FEMA.

Radiological Emergency Preparedness

NRC is responsible for "onsite" activities—those that take place at the power plant. FEMA is responsible for "offsite" activities—State and local government emergency preparedness activities that take place beyond the plant boundaries. Within this role, FEMA:

- Reviews and evaluates offsite radiological emergency response plans (RERPs) developed by State and local governments.
- Evaluates radiological emergency planning (REP) exercises conducted by State and local governments to determine whether their RERPs can be implemented.
- Reports to the NRC on the adequacy of offsite emergency planning and preparedness.
- Coordinates the activities of Federal agencies involved in the radiological emergency planning process.

REP exercises are designed to test the capability of offsite response organizations (OROs) to protect public health and safety through the implementation of their RERPs under simulated conditions.

FEMA's evaluation of REP exercises is an important element in ensuring State and local jurisdictions' readiness for radiological emergencies.

Nuclear Facilities

In September 2002, 104 commercial nuclear power reactors were licensed to operate in the U.S. Those nuclear facilities are:

- Located in 31 states.
- Spread through the eastern half of the country, with a few in the West.

Effective emergency response depends on grading the level of emergency and then responding accordingly. Emergency Classification Levels (ECLs) were developed for this purpose.

Emergency Classification Levels

Emergency Classification Levels (ECLs) stem from Emergency Action Levels (EALs). An EAL is an onsite observable measure that a nuclear facility uses to determine how and when it should notify the offsite emergency response organizations. Each nuclear power utility establishes its own specific conditions or instrumentation readings—according to guidelines set by the NRC—that will initiate a particular EAL.

The Four ECLs

When an EAL is initiated, it triggers the utility to declare the corresponding ECL. There are four Emergency Classification Levels:

Notification of Unusual Event (NOUE)

NOUE—the lowest emergency level—can be triggered by any problem within the plant that could potentially lead to a degradation in the level of safety. No release of radioactive material is expected at the time of the event, although conditions could deteriorate in the future. Because no release is expected, offsite emergency workers should not have to monitor for a release. Remember, though—an event can begin as a NOUE and then escalate.

Alert

Alert is the second lowest emergency level. The difference between an Alert and a NOUE is that a release may be possible under an alert. However, such a release is expected to be small and limited to a fraction of the EPA Protective Action Guides (PAGs). (We'll learn more about PAGs later in this lesson.) An event can escalate from the Alert level if safety conditions deteriorate further, or it can deescalate.

Site Area Emergency (SAE)

An SAE indicates a serious safety condition at the plant. With this type of event:

- Major safety systems have failed or are about to fail.
- A release is possible but is not expected to exceed EPA Protective Action Guides (PAGs), except at the site boundary.
- Plant conditions are such that radiation levels within the plant boundaries could exceed the PAGs.

General Emergency (GE)

GE is the highest emergency level. In this type of event:

- The core would be either damaged or expected to become damaged.
- A release could be imminent and could exceed Environmental Protection Agency (EPA) PAGs. However, there could be a General Emergency without a release occurring.

Plants in the U.S. were designed to ensure core integrity. A plant whose core becomes damaged may be operating outside its design specifications, and operators might not know how to fix the problem.

Event Frequency

Unusual events of the four types just described are relatively rare in the U.S. The more serious the event, the more rare its occurrence. The following chart shows how many events of each type have occurred over a recent 5-year period and overall since 1989.

Classification of Events Under Reactor Licensee Emergency Plans						
Event / Year	**1997**	**1998**	**1999**	**2000**	**2001**	**1989-2001**
NOUE	40	26	34	18	13	1174
Alert	3	4	4	1	3	89
SAE	0	0	0	0	0	5
GE	0	0	0	0	0	0

Protective Actions

One of the distinctions between the various ECLs relates to whether Protective Action Guides (PAGs) are likely to be exceeded.

What Are Protective Actions?

In responding to radiological emergencies, public officials are faced with making decisions and taking actions to protect the public from the potentially damaging effects of radiation. A ***protective action*** is an action taken to avoid or reduce the radiation dose when the benefits are sufficient to offset any undesirable features of the protective action. Protective actions can be taken to fulfill several different objectives, including:

- To remove or keep people from the area where exposure to radiation could occur.
- To shield people from the radioactive release.
- To limit the damage caused by a certain type of radiation exposure.
- To limit the amount of radioactive material ingested through food.

Examples of protective actions include:

- Evacuation
- Sheltering
- Access control
- Use of potassium iodide (KI)
- Use of stored feed and protected water for animals
- Condemnation of food supplies
- Relocation
- Decontamination
- Plant Conditions

OROs use the best information available at the time of an incident to make decisions about protective actions. The urgency with which decisions must be made can vary greatly, depending on situational factors such as the ECL and how quickly the event is unfolding.

Time Factors

It appears to take a minimum of about a half-hour from the initiating event before a release could occur, as indicated in the following table. Response time must be fast enough to react within this time if necessary.

Time Factors Associated with Release	
Time from initiating event to start of atmospheric release	0.5 to several hours
Period during which radioactive material may be continuously released	0.5 hours to several days
Time at which the major portion of a release may occur	0.5 hours to 1 day after start of release
Time for release to reach exposure points:	
. . . at site boundary	minutes
. . . at 5 miles	0.5 to 2 hours
. . . at 10 miles	1 to 4 hours

Protective Action Guides

In 1991, the U.S. Environmental Protection Agency (EPA) published the *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents.* The manual assists public officials in planning for emergency response to nuclear emergencies within the required timeframe.

A ***Protective Action Guide (PAG)*** is the projected dose to individuals in the population that warrants taking protective action. Projected dose means the dose that would be received if no protective actions were taken.

A PAG answers the question, "What level of likely radiation exposure would warrant our taking this particular protective action (for example, evacuation)."

Considering the Risks

PAGs are established to minimize health risks, both immediate and delayed. They have two broad goals: to avoid **immediate** health risks and to keep the risk of **delayed** health effects within upper bounds that adequately protect public health under emergency conditions and that are reasonably achievable.

PAGs do not imply an acceptable level of risk. They also do not represent a boundary between safe and unsafe conditions. Rather, PAGs are the approximate levels at which the associated protective actions are justified. PAGs are used only in an effort to minimize the risk from an event that is occurring or has already occurred.

Nuclear Incident Phases

Protective Action Guides are tied to the time elapsed since the incident began. Nuclear incidents have three phases, which are linear but may overlap:

- The **early phase** (or emergency phase) begins at the start of a nuclear incident when protective actions are required. It ends when the source and release have been brought under control. This phase can last from hours to days.

- The **intermediate phase** begins when the source and the release have been brought under control and ends when protective actions have been terminated. For dose projection, this phase is assumed to last a year.

- The **late phase** (or recovery phase) encompasses the recovery actions designed to reduce radiation levels in the environment to acceptable levels for unrestricted use. It begins when protective actions have ended and may extend from months to years.

PAGs for the Early Phase

For the early phase, the PAGs are based on the total amount of radiation received from two sources:

- External radiation exposure (e.g., groundshine and cloudshine).
- Internal radiation exposure, from inhalation. This type of radiation continues to affect the internal organs once it is inside the body.

In the early phase, the time available to implement the most effective protective actions may be limited. As soon as an incident is known to have occurred, a preliminary evaluation is made to gain information that will enable decisionmakers to decide on the best protective actions. The preliminary evaluation may reveal such information as:

- Nature and potential magnitude of the incident.
- Likelihood of a major release.
- Characteristics of the situation, such as potential exposure pathways, populations at risk, and projected doses.

PAGs of 1 to 5 REM have been established for the early phase, as shown in the table below.

Early Phase PAGs

PAG	Comments
1- 5 REM*	Evacuation (or, for some situations, sheltering). ▪ Evacuation should normally be initiated at 1 REM. ▪ No specific minimum level is set for initiating sheltering. In some cases, sheltering should be considered at projected doses below 1 REM. ▪ Sheltering may be preferred when it provides equal or greater protection. ▪ Sheltering should always be used when evacuation is not carried out at projected doses of 1 REM or more.
* Committed dose equivalent to the thyroid may be 5 times larger; committed dose equivalent to the skin may be 50 times larger. See the glossary for REM and similar terms.	

Other Early Phase PAGs

In addition to these general PAGs, specific PAGs for the early phase have been developed for emergency workers, use of potassium iodide, and ingestion levels.

Emergency Workers

The dose limits for emergency workers are higher than for the general public, for two reasons:

- Emergency workers may need to take more risks (i.e., receive a higher dose) in order to aid the general public.
- Emergency workers usually have potassium iodide and dosimetry to help mitigate this additional risk.
- Emergency workers also get training on radiation.

The dose limits for this group vary from 5 to 25 REM according to the importance of the task being performed. At doses over 25 REM, emergency workers must be made fully aware of the risks involved and may continue to work only on a voluntary basis.

Emergency Worker Dose Limits		
Dose Limit REM	**Activity**	**Condition**
5	All	
10	Protecting valuable property	Lower dose not practicable
25	Life saving, protection of large populations	Lower dose not practicable
>25	Life saving, protection of large populations	Only on a voluntary basis to persons fully aware of the risks involved

Use of Potassium Iodide

Exposure to radioactive iodine poses a long-term risk of thyroid cancer. Potassium iodide (KI) can safely be used to block the thyroid's uptake of radioiodines. Use of KI provides an important means of protection for certain groups, including:

- Institutionalized groups that cannot be evacuated.
- Emergency workers who must remain in the affected area to handle the emergency functions.
- Members of the public—especially children, who are highly vulnerable to thyroid cancer.

In 2002, the Federal policy on use of potassium iodide was revised as follows:

- KI should be stockpiled and distributed to emergency workers and institutionalized persons for radiological emergencies at a nuclear power plant.
- Use of KI should be considered for the general public within the 10-mile emergency-planning zone of a nuclear power plant.
- The decision on whether to use KI for the general public is left to the discretion of States and, in some cases, local governments.

Ingestion PAG

The ingestion PAG applies primarily to food and water. The ingestion PAG is 0.5 REM committed effective dose equivalent or 5 REM committed dose equivalent to an individual tissue or organ—whichever is more limiting. The FDA recommends a combination of two approaches—Derived Intervention Levels (DILs) and protective actions—to limit the radiation dose received from consuming contaminated food.

DILs

DILs are limits on the radionuclide concentration permitted in food. DILs apply during the first year after a release.

Protective Actions

Protective actions are taken to reduce the amount of contamination. They are initiated immediately, subject to evaluation of the situation, and continue until concentrations (in the absence of the actions) remain below the DILs.

Ingestion Protective Actions

The protective actions for a specific incident are determined by the particulars of the situation. Once initiated, they continue at least until the concentrations are expected to remain below the DILs.

Prior to Confirmation of Contamination

Protective actions can be taken before the release or arrival of contamination if contamination of the environment is expected. The ECL (NOUE, Alert, SAE, and General Emergency) may be helpful for selecting appropriate measures. Appropriate actions prior to confirmation of contamination are likely to be confined to (1) simple precautionary actions to avoid or reduce the potential for contamination of food and animal feeds and (2) temporary embargoes to prevent the introduction into commerce of food which is likely to be contaminated. Examples include:

- Covering exposed products.
- Moving animals to shelter.
- Corralling livestock.
- Providing protected feed and water.

Foods Confirmed as Contaminated

Protective actions which should be implemented when the contamination in food equals or exceeds the DILs consist of (1) temporary embargoes to prevent the contaminated food from being introduced into commerce and (2) normal food production and processing actions that reduce the amount of contamination in or on food to below the DILs. Examples include:

- Holding food products to allow for radioactive decay.
- Removal of surface contamination by brushing, washing, or peeling.
- Avoiding blending contaminated food with uncontaminated food.
- More complex processing procedures to reduce contamination.

Animal Feeds Confirmed as Contaminated

Protective actions to reduce the impact of contamination in or on animal feeds (including pasture and water) are taken on a case-by-case basis. Examples include:

- Substituting uncontaminated water for contaminated water.
- Removing lactating dairy animals and meat animals from contaminated feeds and pasture.
- Substituting uncontaminated feed.
- Corralling livestock in an uncontaminated area.

PAGs for the Intermediate Phase

After the emergency has been brought under control, the focus shifts to protecting the public from whole body external exposure due to deposited material and inhalation of resuspended particulates. The major protective actions considered at this stage include:

- Relocation.
- Decontamination.
- Food and water restrictions.

In this phase the key issue is: What level of radiation should prompt a decision to relocate the population rather than allow them to live in the area that has been contaminated?

EPA advises simple dose reduction techniques if the projected dose is less than 2 REM for the first year, and relocation if the projected dose is greater than 2 REM for the first year.

Emergency Planning Zones

Emergency Planning Zones (EPZs) are generic areas around a nuclear facility for which planning is needed to ensure that prompt and effective actions can be taken to protect the public in the event of a nuclear incident.

EPZs are generic areas, not fixed distances or precise circles. The exact size and configuration of the EPZs surrounding a particular nuclear power facility are determined by State and local governments in consultation with FEMA and NRC. In establishing the size and shape of the EPZs, planners take local factors into account. Examples of planning factors include:

- Demography
- Topography
- Land characteristics
- Access routes
- Local jurisdiction boundaries

In reviewing emergency plans in your role as evaluator, you will see two different EPZs: the Plume EPZ and the Ingestion EPZ.

Plume EPZ

The plume EPZ is established for the short-term "plume exposure pathway." It is usually a 10-mile radius around the facility. This size of zone was selected because:

- Projected doses from design basis accidents and most core melt accidents would not exceed PAGs outside this zone.
- Worst-case melt accidents would not result in immediate life-threatening doses outside this zone.
- Detailed planning would provide a base for expanding response efforts, if necessary.

Plume phase exercises are evaluated by FEMA every 2 years.

Ingestion EPZ

The ingestion EPZ—designed for the longer-term "ingestion exposure pathway"—is usually a 50-mile radius around the nuclear facility and includes the plume EPZ. In this zone, the primary concern is radiological materials deposited on the ground and contaminating food and water. This size of the ingestion EPZ was chosen because:

- The likelihood of exceeding the ingestion pathway PAG levels at 50 miles is about the same as for exceeding the plume exposure pathway PAGs at 10 miles.
- Wind shifts during and after a release would limit the downwind range to 50 miles.
- Atmospheric iodine may convert to chemical forms that are not easily ingested.
- Most particulate material would be deposited on the ground within 50 miles.

Post-plume phase exercises are evaluated once every 6 years.