

**NEI White Paper**  
**Range of Protective Actions for Nuclear Power Plant Incidents**

**1.0 Purpose:**

To detail the range of early phase protective actions that may be used for nuclear power plant incidents.

**2.0 Discussion:**

**2.1 History**

The range of protective actions that would be used to protect the public during a nuclear power plant incident has been based on a strategy of evacuation and sheltering since emergency plan development nearly 25 years ago. This paper will not attempt to recount past strategies or their associated bases, but will examine the protective actions detailed in current guidance.

**2.2 Current Guidance**

10 CFR 50.47(b)(10) (Ref 1) contains the requirement for a licensee's emergency plan to contain a range of protective actions. Guidance to implement a range of protective actions was revised in the mid 1990's in response to the issuance of NUREG 0654 Supplement 3 (Ref 2), EPA 400 (Ref 3), and in 2001 to accommodate a change to 10 CFR 50.47 (Ref 1).

Each of the subject guidance documents contains the same basics concepts of evacuation and sheltering as protective actions. However, sufficient ambiguity exists within the guidance to have resulted in divergent implementation of protective action schemes within the industry. Specifically, the indications for, and implementation of, each protective action differs among licensees. The remainder of this section examines the features of each guidance document.

**2.2.1 EPA 400**

EPA 400 retained the concepts of evacuation and sheltering as protective actions from previous guidance. EPA 400 revised the Protective Action Guidelines (PAG) (Ref 3 Table 2-1) and provided a basis for those guidelines (Ref 3 Appendices B and C). That document did not effectively link its revised guidance to nuclear power plant conditions, such as emergency action levels or emergency classification levels, nor did it provide specific guidance on how to use the diverse implementation concepts it contained. In the absence of such guidance, many nuclear power plant licensees, in consultation with offsite officials, provided their own interpretation of when and how the PAG's would be utilized. This resulted in multiple different implementation schemes being implemented by licensees. In addition, dose and dose rate terminology used in EPA 400 differed from that used in a companion revision to 10 CFR 20 (Standards for Protection Against Radiation).

Evacuation is defined as physically removing people from a location where exposure to radiation is possible. EPA 400 recommends evacuation as the principle method of protecting the public and provided an analysis of the benefit of evacuation versus health effects from radiation (Ref 3 Appendix C). The document provides specific details regarding when evacuation should be recommended.

Sheltering is defined as actions taken by members of the public to reduce their exposure to radiation and radioactive materials while remaining in place. EPA 400 recommends sheltering as an alternative during certain conditions such as short-duration releases or in the presence of evacuation hazards such as weather or road conditions, or for special populations (Ref 3 section 2.3.1). The reference notes that the effectiveness of sheltering varies widely due to protection factor as a function of building construction, varying effectiveness of air infiltration blocking methods, and air exchange with a structure. EPA 400 notes multiple mechanisms that would cause sheltering to not provide a large protection factor, and provides a caution against use of this protective action. The document provides general guidance for when sheltering should be recommended and what actions the public would take to implement it, but stops short of specific guidance on protective action initiation and implementation.

### 2.2.2 NUREG 0654 Supplement 3

This document was issued two years after EPA 400 and was intended to simplify and clarify previously issued guidance. This guidance references the dose-based protective action concepts in EPA 400, but relies primarily on plant conditions as an indication for protective actions. NUREG 0654 is aligned with EPA 400 with respect to sheltering, recommending it as an alternative to evacuation for short term releases or when impediments to evacuation exist.

Protective action guidance is summarized in Figure 1 of that document and calls for immediate evacuation of parts of the EPZ in the event of “Actual or projected severe core damage or loss of control of facility”. Such conditions are considered to exist coincident with a General Emergency classification level. The subject figure also recommends “Sheltering...for controlled releases of radioactive material...if there is assurance that the release is short term...”. In addition, Figure 1 implies sheltering for populations that should be evacuated “...unless conditions make evacuation dangerous...”.

Figure 1 also introduces a new concept to EPZ populations not evacuated or sheltered by recommending that “...advise remainder of plume EPZ to go indoors to monitor EAS broadcasts.” This concept is typically called “heightened awareness”. This action prepares the public for an evacuation, if necessary, and improves the efficacy of the evacuation process. The action itself does not provide protection to the public, and is not considered a protective action, though licensees may include this action under recommended protective actions.

Section III of this document discusses the use of previous guidance (Appendix 1 to NUREG 0654 (Ref 2) and the subsequent Information Notice 83-28). That section states that the referenced schemes “...can continue to be used with the proper understanding of the concepts underlying the development.” The older guidance recommends the evacuation of a 5-10 mile downwind sector under certain severe accidents. The industry position detailed in section 2.3.1 is considerate of this recommendation.

### 2.2.3 10 CFR 50.47(b) (10):

This regulation was amended in 2001 to include the consideration for the use of thyroid prophylaxis. It required states to formally consider the inclusion of potassium iodine (KI) as a thyroid blocking agent and incorporate it into their emergency plans as appropriate. Given this, KI would only be included in the licensees range of protective actions if the affected State(s) decided to include it.

### 2.2.4 Summary of requirements and guidance

Table 1 provides a summary of the guidance, including indications and implementation.

		Evacuation	Sheltering	KI	Heightened Awareness *
10 CFR 50.47	<i>When to implement</i>	Not provided	Not provided	Dependent on state/local decision to use	Not mentioned
	<i>How to implement</i>	Not provided	Not provided	Not provided	Not mentioned
EPA 400	<i>When to implement</i>	<ul style="list-style-type: none"> <li>Table 2-1: dose based</li> <li>Evacuate general population at dose of 1 rem TEDE or &gt;</li> <li>Special populations may be evacuated at higher doses</li> </ul>	<ul style="list-style-type: none"> <li>Preferred when it will provide protection equal to or greater than evacuation</li> <li>Consider implementing at doses &lt; 1 rem TEDE</li> <li>Consider when doses &gt; 1 rem TEDE but cannot evacuate due to impediments</li> </ul>	Projected thyroid dose > 25 rem CDE <sub>T</sub>	Not mentioned
	<i>How to implement</i>	Not provided	<ul style="list-style-type: none"> <li>Provides multiple actions to limit infiltration of outside air into structure</li> </ul>	Not provided	Not mentioned

		Evacuation	Sheltering	KI	Heightened Awareness *
NUREG 0654 Supp3	<i>When to implement</i>	<ul style="list-style-type: none"> <li>Actual or projected severe core damage or loss of control of facility</li> <li>Consider EPA PAG's in modifying initial protective actions</li> </ul>	<ul style="list-style-type: none"> <li>When conditions exist that make evacuation dangerous</li> <li>For short term (puff) releases for populations near the plant</li> <li>Transit dependent persons awaiting transportation</li> </ul>	Not provided	Recommend to EPZ populations that have not been advised to evacuate
	<i>How to implement</i>	Not provided	Not provided	Not provided	Advise population to go indoors and listen to EAS

\* Not considered a protective action, but included for completeness

## 2.3 Industry issues

### 2.3.1 Evacuation

Issue 1: Evacuation triggers

EPA 400 (Ref 3) utilizes dose limits as a trigger for evacuation. NUREG 0654 (Ref 2) uses plant conditions as the trigger for evacuation, stating that evacuation should take place when, "...Actual or projected severe core damage or loss of control of facility", and advises to consider EPA PAG's to modify protective actions. Most licensees have interpreted the above guidance to mean: evacuate 2 miles around and five miles downwind at a General Emergency (actions based on plant conditions), then evacuate if actual or projected doses of  $\square$  1 rem total effective dose equivalent (actions based on dose). This interpretation is consistent with the definition of a General Emergency (Ref 4 and 5) and the guidance in NUREG 0654 (Ref 2) that suggests consideration of EPA PAG's.

***Industry Recommendation:***

***The minimum recommendation that should be made at a General Emergency is to evacuate 2 miles around and 5 miles downwind from the plant. Subsequent recommendations should be based on the EPA PAG's, changing plant conditions or changes in wind direction.***

### 2.3.2 Sheltering

Issue 2: Use of sheltering as an alternative to evacuation for short term releases.

Both NUREG 0654 (Ref 2) and EPA 400 (Ref 3) suggest that sheltering be performed for short term (puff) releases or when it provides a benefit greater than evacuation. In the context of emergency conditions, prediction of release duration is difficult. Continuous and rapidly changing conditions, lack of or inaccurate instrumentation and uncertainty of the timeliness and effectiveness of mitigative actions make such a prediction inherently inaccurate. Moreover, choosing to shelter a population rather than evacuate based on erroneous release duration estimation can result in significant health effects on that population.

***Industry Recommendation:***

***A licensee may choose to not integrate the use of sheltering for short term releases into their protective action recommendation scheme.***

Issue 3: Use of sheltering for special populations and impediments.

EPA 400 (Ref 3) provides guidance to shelter when doses are > 1 rem but evacuation is impractical due to impediments. It lists impediments such as severe weather, long mobilization times (such as medical patients or prisoners and guards) or traffic issues (inadequate roads). Similarly, NUREG 0654 (Ref 2) suggests sheltering when conditions exist that make evacuation dangerous or for transit dependent persons awaiting transportation. Though the industry is in general agreement with the guidance, the noted constraints are typically assessed by the local or state agencies responsible for the protective action decision. Licensees are unlikely to be aware of the noted constraints, especially early in an emergency.

Thus, licensees will not typically be in a position to make specific recommendations regarding the use of sheltering.

***Industry Recommendation:***

***Licensees should incorporate sheltering into their emergency plans consistent with existing guidance, noting that the use of sheltering as an alternative to evacuation is a decision that will be made by offsite officials. Implementation of the licensee emergency plan commitment should incorporate allowance for offsite officials to utilize sheltering as an alternative to evacuation at their discretion, in accordance with the guidance. These plans should be developed and maintained in collaboration with those offsite officials. Thus, licensees will typically recommend evacuation as dictated by the guidance, but will incorporate the proviso that the use of sheltering as an alternative is a local or state decision, and is acceptable.***

Issue 4: Effectiveness of sheltering

EPA 400 (Ref 3) contains a significant range of guidance regarding the effectiveness of sheltering (“...almost 100 percent to zero...”). That guidance also contains diverse practical suggestions regarding maximizing the effectiveness of sheltering. In addition, circumstances are detailed as to when sheltering is ineffective. The diversity of this guidance, likely issues of public compliance with detailed sheltering instructions and time constraints on protective action decision processes cause the industry to question the usefulness of detailed sheltering instructions or the development of “sheltering versus evacuation” calculations. The industry favors a qualitative approach to sheltering that utilizes simple instructions to the public for implementation.

***Industry Recommendation:***

***Licensee or offsite officials may opt to utilize a range of sheltering implementation schemes, including:***

- ***The use of qualitative methods for determining the effectiveness of sheltering. Example, if certain plant or radiological conditions exist, then shelter, OR***
- ***The use of quantitative methods for determining the effectiveness of sheltering. Example, the comparison of sheltering versus evacuation doses.***
- ***Utilization of simple public instructions. Example: stay indoors and limit outside sources of air, OR***
- ***Utilization of more complex public instructions. Example: in addition to the above simple instructions, recommend going into a basement or more substantial building, use of respiratory protection.***

**2.3.3 Use of KI for the General Public**

No industry issues associated with the implementation of the action

**2.3.4 Heightened Awareness**

Issue 5: Use of Heightened Awareness

The industry recognizes the value of heightened awareness as preparation to an effective evacuation as detailed in NUREG 0654 (Ref 2)

***Industry Recommendation:***

***Licensees should incorporate the use of heightened awareness in their protective action schemes consistent with the guidance and offsite agency plans.***

**3.0 Conclusion**

The requirement to have a range of protective actions is contained in 10 CFR 50.47(b)(10). EPA 400 and NUREG 0654 serve as guidance for implementation of the requirement. From this, the range of protective actions that should be included in each licensee's emergency plan are:

- Evacuation
- Sheltering (to be used by local and state officials within the caveats stated in the industry position)
- KI (as determined by individual states)

The protective action scheme should make use of heightened awareness in order to maximize the efficacy of evacuation, consistent with the above caveats.

#### **4.0 References:**

(Ref 1) 10 CFR 50.47(b)(10): A range of protective actions including sheltering, evacuation and prophylactic use of iodine have been developed for the plume exposure pathway EPZ for emergency workers and the public. Guidelines for the choice of protective actions during an emergency, consistent with Federal guidance, are developed and in place and protective actions for ingestion pathway EPZ appropriate to the locale have been developed (66 FR 5440, Jan 19,2001)

(Ref 2) NUREG 0654 FEMA REP 1 Supplement 3: Criteria for Preparation and Evaluation of radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants-Criteria for Protective Action Recommendations for Severe Accidents (July 1996)

(Ref 3) EPA 400-R-92-001: Manual of Protective Action Guides and Protective Actions for Nuclear Incidents (October 1991)

(Ref 4) NUREG 0654 FEMA REP 1: Criteria for Preparation and Evaluation of radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants-Criteria for Protective Action Recommendations for Severe Accidents, Appendix 1 Emergency Action Level Guidelines. (November 1980)

(Ref 5) NEI 99-01: Methodology for Development of Emergency Action Levels (September 2002)