NUREG/CR-6863
SAND2004-5900

Development of Evacuation Time Estimate Studies for Nuclear Power Plants

Manuscript Completed: December 2004
Date Published: January 2005

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Prepared for
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Washington, DC 20555-0001
NRC Job Code J3103

Abstract

Since the publication of NUREG/CR-4831, *State of the Art in Evacuation Time Estimate Studies for Nuclear Power Plants*, technologies supporting the development of Evacuation Time Estimates (ETEs) have substantially changed and additional evacuation considerations have emerged. ETEs are part of the planning basis for each nuclear power plant (NPP), and as such, ETE studies are required to be performed by licensees to estimate the time needed to evacuate the public in the unlikely event of a serious accident. As advancements in new technologies that support evacuations and evacuation planning continue, and as new information on evacuations becomes available, it is important that these technologies and information be considered in development of an ETE.

sectors that encompass the entire area (see Figure 1), and are subdivided at about 3.2 and 8 km (about 2 and 5 miles).

The wind direction at the time of the incident will determine the impacted sectors. An evacuation of the 3.2 km (about 2 mile) radius and the downwind sectors will form a keyhole configuration. Wind direction may vary within the EPZ and local assessment of the wind conditions may support limiting the sectors of the evacuation to the sector containing the plume and a single sector on either side, or may require expanding the area of evacuation to include additional sectors. It is important to understand the meteorological assessment capabilities within the EPZ for potential use in development of scenarios. The plume exposure pathway is the about 16-km (about 10-mile) EPZ, and the area affected is generally the sector or sectors that the plume touches and the adjoining sectors on either side.

2.1.1 Emergency Response Planning Areas

Emergency Response Planning Areas (ERPAs) are defined areas located within the EPZ for which emergency response plans have been developed. These areas are typically defined by geographic or political boundaries to support emergency response planning and may also be referred to as subareas, protective action areas, or other local terminology. There may be several ERPAs depending on the specific characteristics of the EPZ. Figure 1 identifies a conceptual layout of 11 ERPAs within an EPZ. State and local emergency response agencies provide evacuation information to the public through calendars and other means. It is important to engage these agencies early to ensure that data and assumptions used in the ETE calculations are consistent with the response plans.

Protective actions are typically implemented by ERPA. In the event of an evacuation, the sectors to be evacuated will cross ERPA boundaries. Each of the ERPAs that are within the affected sectors would be evacuated. Data obtained at the ERPA level should be used in calculating the ETE for the evacuated area identified in each scenario.

2.2 Demand Estimation

Demand estimation is the systematic approach used to identify the total number of evacuees by assessing population groups and the expected mode of transportation. Demographic data, together with information and assumptions on population groups and vehicle occupancy rates, support determination of the number of vehicles that will be evacuating the area.

Evacuation trips do not begin instantaneously after a warning to evacuate. There is a delay between the time the public is notified to evacuate and the time at which the actual evacuation begins. This delay varies by population segment, person, household, time of day, and location, and will influence traffic loading rates onto the transportation network. The traffic loading rate represents the number of vehicles that would attempt to enter the roadway network at any given time after the evacuation notification, and it should be treated as a probability distribution in the ETE calculation. Telephone surveys, using a statistically defensible sample size, can provide better data than generalized assumptions. This approach will reduce the uncertainty in the demand estimation.

There are a variety of ways to estimate populations; therefore, it is necessary to document the approach and provide sufficient detail on the basis for the population data used. For the demand estimation, three potential population segments shall be considered: permanent residents, transients, and persons in special facilities (NRC, 1980a). Permanent residents include those people having a residence in the area. The permanent resident population is generally derived

from census data. The Census Bureau is currently making a transition to supplement the decennial data on an annual basis for large urban areas and on a five-year basis for rural and small urban areas. This may provide a means to obtain more current population data for developing and updating ETEs. The Census Bureau also maintains data on populations with disabilities which may be helpful in determining special transportation needs. The number of permanent residents shall be estimated using the U.S. Census data or other reliable data, adjusted as necessary, for growth (NRC, 1980a).

The transient population group includes visitors, tourists, shoppers, employees not residing in the area, and other people visiting the area temporarily. The diversity of this group requires a variety of means to estimate the population and may require a different approach for each segment of the transient population. The first task is to identify the potential transient locations, including businesses, shopping centers and malls, parks, recreation facilities, and special events, where applicable. Once the transient locations are identified, a systematic approach to determining the population of the group should be employed. Seasonal characteristics of the transient group should be considered. For instance, some parks or beaches may be closed during the winter months, and thus should not be included in that scenario. Care should be taken not to double count transient populations. For example, motel capacities may be full in the evenings, but empty during the day when tourists are visiting parks or other areas that will be included in the capacity calculations.

To determine the number of employees who work in the EPZ, but do not live in the EPZ, statistically defensible surveys may be necessary, combined with local and state statistical data. Some malls and shopping centers maintain statistics on the number of shoppers. In some cases, it may be necessary to count parking spaces to estimate populations for these facilities. State parks frequently keep data on the number of visitors per year and per season. If this information is not available, counting parking spaces may support the population estimate. Care should be taken to avoid double counting vehicles belonging to permanent residents who use the facilities.

Special facilities include schools, day care centers, hospitals, nursing homes, prisons, and any special events facilities. A detailed list of special facilities should be developed in order to assess each facility on an individual basis. The population estimate for these facilities may be obtained by contacting the facilities and should consider the maximum occupancy rates. A percentage of this population may be expected to be evacuated by family or friends rather than by public transportation; however, care should be taken not to underestimate special transportation needs.

Seasonal changes for schools and day care centers should be considered. Special facilities will have individual transportation requirements for evacuation, which may include buses, vans, ambulances, and automobiles. Furthermore, some special facilities may relocate their residents to other special facilities outside of the EPZ, such as prisons and hospitals, which may be a considerable distance away. This may increase the time to evacuate a facility if return trips are necessary. In some cases, double counting is necessary, such as school children who are counted as permanent residents and as special facility populations, because in some scenarios the school children may evacuate from school and in other scenarios they may evacuate from home (NRC, 1992).

In addition to the three defined population groups, returning commuters and vehicles traveling through the area during the event should also be considered. Returning commuters include permanent residents who work outside the EPZ and return home before evacuating as a family group. Residents of the EPZ who are not at home (i.e., shopping, at parks, etc.) at the time of the evacuation notice may also return home prior to evacuating. Similarly, when special events occur within the EPZ, residents attending these events may return home prior to evacuating.