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EVACUATION PLANNING FOR NUCLEAR POWER PLANT EMERGENCIES AND ANALYSIS APPROACHES FOLLOWED IN ESTIMATING THE EVACUATION TIME

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NÜKLEER SANTRAL KAYNAKLI ACİL DURUMLAR İÇİN TAHLİYE PLANLAMASI VE TAHLİYE SÜRESİNİN BELİRLENMESİNDE KULLANILAN ANALİZ YAKLAŞIMLARI

Abstract:

Evacuation with the use of iodine tablet is the most preferred protective action before the release of radioactive material for those living in emergency planning zones during general emergency situations that may occur in all nuclear power plants with thermal power higher than 100 MW. In this way, deterministic health effects on people living in the region can be prevented and radiation doses above the international generic criteria for the implementation of protective actions and other response activities may be prevented. In this context, during the preparation of emergency plans for nuclear power plant emergencies, evacuation plans and analyses to determine the evacuation time estimate gain importance.

In this study, the issues that need to be emphasized during the evacuation planning studies are explained and the information about the presentations of these studies in the emergency plans are given on the basis of scientific articles and regulatory and technical documents issued in USA. While explaining the issues related to the calculation of the evacuation time estimate, the topics such as the generation of demand estimates, determination of roadway capacity and analysis methods to be used were focused on. The current situation in Turkey regarding the evacuation planning and evacuation time estimate studies related to the nuclear power plant emergencies is explained. Within the scope of the studies it was concluded that the evacuation delay factors specific to the country or region where the nuclear power plants are located should be taken into consideration in addition to the issues stated in the relevant regulatory and technical documents. The important factors specific to Turkey are considered to be special locations of the highly populated residential areas in the emergency planning zones, high number of settlements in the rural areas of the emergency planning zones, the nomadic people and livestock belonging to residents of the emergency planning zones.

Özet:

Termal gücü 100 MW ve üzerinde olan tüm nükleer santrallerde meydana gelebilecek genel acil durumlar sırasında acil durum planlama bölgeleri içinde yaşayanlar için radyoaktif madde salımının meydana gelmesinden önce iyot tableti kullanımı ile beraber uygulanacak tahliye işlemi en çok tercih edilen koruyucu eylemdir. Bu sayede, bölgede yaşayan insanlar üzerinde oluşabilecek deterministik sağlık etkileri engellenebilir ve acil koruyucu eylemler ile diğer müdahale faaliyetlerinin uygulanmasına ilişkin uluslararası genel kriterlerin üzerinde

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radyasyon dozlarının alınması önlenebilir. Bu kapsamda, nükleer santral kaynaklı acil durumlar için acil durum planlarının hazırlanması sırasında tahliye planlamaları ve tahliye süresinin belirlenmesine yönelik analizler önem kazanmaktadır.

Bu çalışmada, tahliye planlamalarına dair çalışmalar yapılırken üzerinde durulması gereken hususlar açıklanmış ve bu çalışmaların acil durum planlarındaki sunumları hakkındaki bilgiler konuya ilişkin bilimsel makaleler ve ABD'de yayımlanan düzenleyici ve teknik dokümanları temel alınarak verilmiştir. Tahliye süresinin belirlenmesi ile ilgili konular açıklanırken talep tahminlerinin oluşturulması, trafik kapasitesinin belirlenmesi ve kullanılacak analiz yöntemleri başlıklarının üzerinde durulmuştur. Nükleer santral kaynaklı acil durumlarda tahliye planlaması ve tahliye süresinin belirlenmesi kapsamında Türkiye için mevcut durum açıklanmıştır. Tahliye planlaması ve tahliye süresinin belirlenmesi ile ilgili çalışmalar kapsamında konuya ilişkin düzenleyici ve teknik dokümanlarda yer alan hususların yanı sıra nükleer santrallerin yer aldığı ülke veya yöreye özel tahliyeyi geciktirici etkenlerin de dikkate alınması gerektiği sonucuna varılmıştır. Türkiye için bu özel faktörlerden önemlilerinin yerleşim merkezlerinin özel konumları, acil durum planlama bölgelerinde yüksek sayıda kırsal yerleşim bulunması, konargöçerler ve acil durum planlama bölgelerinde yaşayanlara ait çiftlik hayvanları olduğu değerlendirilmiştir.

Keywords: Nuclear power plant, emergency, protective action, evacuation planning, evacuation time estimate, demand estimation, roadway capacity

Anahtar Kelimeler: Nükleer santral, acil durum, koruyucu eylem, tahliye planlaması, tahliye süresinin belirlenmesi, talep tahminleri, trafik kapasitesi

1. Introduction

Evacuation, as a protective action, performed prior to the release of radioactive material during a nuclear power plant emergency can effectively protect the public and workers from all means of radiation exposure. Evacuation also ensures that people are removed from emergency planning zones, so that they are not perceived as a direct concern by emergency response managers.

The analyses (IAEA, 2013) have shown that, iodine tablet can be taken and sheltering action can be performed until evacuation can be implemented safely in case the evacuation action during an emergency cannot be carried out safely due to various reasons (the evacuation routes might be blocked due to snow storm or floods, special facilities such as hospitals cannot be evacuated, etc.). Sheltering in large buildings can prevent the lethal radiation doses and reduce the radiation doses that could be taken by all pathways (IAEA, 2013). However, a study in the literature (U.S. NRC, 1987) has shown that evacuation performed at walking velocities (5 km/h) and above are more effective than sheltering, even if these evacuation operations are carried out under airborne radioactive substances present after release. Therefore, evacuation operations that can be carried out safely during a general emergency (IAEA, 2013) should not be postponed.

Traffic jams and "shadow evacuations" during evacuation actions (self-evacuation by the public who do not need to be evacuated and who have not received any instructions to do so) may prevent the rapid evacuation of emergency planning zones (Lee et al., 2016). Therefore, traffic jams and shadow evacuations should be taken into consideration and evacuation actions should be carried out in a phased manner, giving priority to evacuation of those living in

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emergency planning zones to outside the zones. Evacuation of those living outside the planning zones should be implemented in a way that does not delay the evacuation of the planning zones.

Past emergencies (radiological or non-radiological ones) have shown that evacuation actions can be implemented quickly, even without prior planning (U.S. NRC, 2005). However, the evacuation of patients and people in need of special care may endanger their lives if they are not carried out under an emergency planning (Tanigawa et al., 2012). It is appropriate to evacuate patients and people under special care within the emergency planning zones to places outside the extended planning distance, without requiring further evacuation.

When the documents in the literature are examined, it is seen that the following issues should be taken into consideration during the planning (preparation) studies for the implementation of evacuation actions:

- Determination of the operational criteria to be used when making decisions regarding the implementation of the evacuation action
- Determination of evacuation routes and traffic control
- Control of entrances to and exits from the evacuated areas and ensuring the security of property of evacuated people
- Preparation for evacuation of special facilities such as hospitals and nursing homes and people in need of care
- Consideration of livestock and domestic animals
- Making necessary preparations to meet the humanitarian needs of the evacuated people

When the above mentioned topics are examined, it was seen that these documents do not include any provision stating that the factors that could delay the evacuation actions specific to the country or region where the nuclear power plant is located should be taken into consideration during evacuation planning.

Considering the issues discussed in this section, evacuation planning is very important for the timely implementation of the evacuation during nuclear power plant emergencies. In this study, it is aimed to provide detailed information about evacuation planning and determination of evacuation time estimate to be performed in support of these plans, on the basis of regulatory and technical documents. Apart from the most of the related studies in the literature, the importance of country or region specific factors that can affect the evacuation planning and time are tried to be pointed out in this study. Moreover, the current situation for Turkey in terms of evacuation planning, implementation of evacuation actions and evacuation time estimate studies during nuclear power plant emergencies is explained together with the factors specific to Turkey that can impact the evacuation actions.

2. Presentation of Information Related to Evacuation Planning and Determination of Evacuation Time Estimate in Emergency Plans and Basic Assumptions Related to These Topics

The sections to be included in the emergency plans for evacuation planning and determination of the evacuation time estimate should first include a detailed map of the region where the nuclear power plant is located, including the emergency planning zones of the plant. This map should include transport networks in the region, topographic elements (forms of natural or artificial details of a land surface) and administrative boundaries. Within the scope of estimation of the evacuation time, all assumptions about the occupancy rate of the vehicles

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used during evacuation, the capacities of the roadways and the population density in the region to be evacuated should be presented. Some general assumptions that can be used in this context are listed below (U.S. NRC, 1980):

- Evacuation time will be measured from the initial notification of the public living in the emergency planning zones.

- Evacuation actions will begin immediately after the first notification.

- Special facilities such as schools, hospitals and nursing homes will also be notified at the same time as the rest of the emergency planning zones.

- Evacuation time will end when the last vehicle used for evacuation leaves the emergency planning zones.

- Most of the private vehicles of the people living in the area will be used during evacuation. Each of these vehicles will be considered to have 2 or 3 persons.

- When the first notification about the emergency situation is made, it will be assumed that there is a normal traffic density on the roadways in the region.

- The occupancy rate of the public transportation vehicles to be used during evacuation shall be accepted as 50%.

- Vehicles (Buses) to be used for evacuation of special facilities such as schools, hospitals and nursing homes will move at full capacity.

- Vehicles (Buses) to be used during the evacuation from the nuclear power plant will also move at full capacity.

- Outside the emergency planning zones inside the 30 km radius of the nuclear power plant, 20% of the people who have not been instructed to evacuate will be considered to have carried out the evacuation action.

If region-specific assumptions are to be used other than those listed above (in particular on the capacities of roadways), these should also be stated.

The approach to be used during the estimation of the evacuation time should be explained in a way that includes the algorithms of the computer aided models to be used during the analyses. In this context, information should be provided on field studies carried out for the recognition of roadways and traffic control systems, sources used to obtain demographic information and traffic control plans used during analyses (U.S. NRC, 2005).

Since the information related to evacuation planning and estimation of the evacuation time will also be used by the decision makers responsible for taking decisions regarding the implementation of evacuation actions during an emergency, these plans and information should be updated periodically or whenever needed, taking into account the local conditions of the region where the emergency may occur and the final condition of emergency preparedness.

3. Evacuation Time Estimate Studies

The studies to be carried out within the scope of estimation of the evacuation time are basically composed of three main stages: the generation of demand estimates, the determination of roadway capacity, and the performance of analyses.

3.1 Generation of demand estimates

The generation of demand estimates should specify the number of persons to be evacuated during an emergency. Four separate population groups should be considered within

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this scope. These are the people living in the region, the people who are temporarily in the region, the people in special facilities such as schools, hospitals and nursing homes, and those who will be evacuated from the nuclear power plant. Persons who have homes in the region should be included in the class of people who live in the region. Tourists, other persons who may visit the region and persons working in the institutions and organizations in the region but whose houses are not located in the region should be considered as persons who are temporarily present in the region. It should be avoided that the same persons are taken into account twice when determining the number of persons for all these population groups (U.S. NRC, 1980).

In the next stage, these populations should be divided into two groups, which can and cannot use their own vehicles during evacuation. During evacuation, the number of private vehicles that will be used by the residents will be determined by assuming that each vehicle has 2 or 3 people. An alternative approach to determine the number of private vehicles to be used by residents in the area during evacuation is to accept the use of a vehicle for evacuation from each of the houses with their own vehicle. For both approaches, special attention should be given to identifying persons who do not have a private vehicle and those who will use public transport.

Different vehicle occupancy rates can be used for each group when determining the number of private vehicles that these people will use during evacuation. Tourists can be assumed to have 3 or 4 persons in each vehicle, while this number can be considered as 1.5 for employees of institutions and organizations. Planning for special facilities and persons to be evacuated from the nuclear power plant should be done separately for each facility and the vehicles to be used for these facilities should be specially determined.

Emergency planning zones can be analyzed by dividing them into sub-areas of equal-angle circle segments (Figure 1) while estimating evacuation times. The total population for each sub-area of the emergency planning zones and the total number of vehicles to be used during evacuation can be shown on such a map. It should be taken into consideration that the evacuation of the neighboring inner evacuation zone areas will be given priority while analyzing the sub-areas in the outer emergency planning zone. The boundaries of these sub-areas can also be determined by taking into account the demographic, topographic characteristics of the region, the routes of roadways and the boundaries of local administrative units. The boundaries of the sub-regions should not, if possible, pass through the regions with high population density. Maps where emergency planning zones are subdivided, can also show locations of the special facilities (U.S. NRC, 2005).

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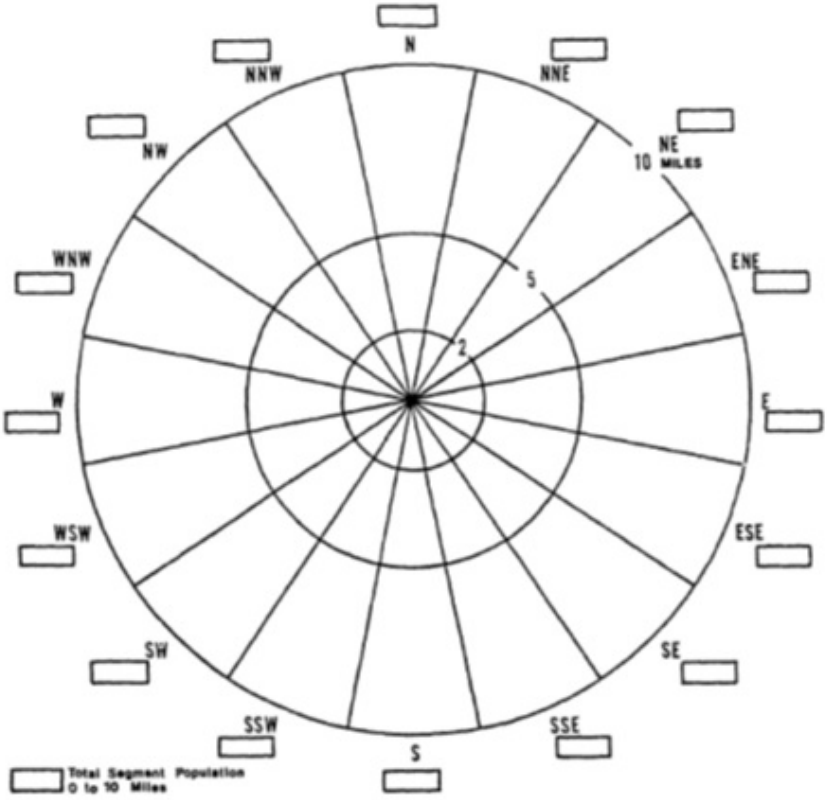

POPULATION TOTALS			
RING, MILES	RING POPULATION	TOTAL MILES	CUMULATIVE POPULATION
0 - 2		0 - 2	
2 - 5		0 - 5	
5 - 10		0 - 10	

Figure 1. Sample Graph for Presentations of Total Population of Sub-Areas of Emergency Planning Zones and Total Number of Vehicles to be Used During Evacuation (U.S. NRC, 1980)

3.2 Determination of roadway capacity

In the determination of the roadway capacity, the roadway network to be used during evacuation should be examined in detail and the locations, types and capacities of all roads in the region should be determined. The average travel times on the roads in the roadway network and the possible points where traffic jams may occur should be identified. During these analyses, all roadway network in the region should be taken into consideration, but the side roads to be used during evacuation should be selected in a way that does not interfere with the traffic on the main roads. Attention should be paid to the fact that not only large motorways are used during evacuation. Alternative routes should be determined as much as possible since the capacity of the access lanes to these roads are limited. It should also be noted that evacuation during an emergency will be carried out in all directions of the emergency planning zones. It should also be taken into consideration that all analyses to be made within the scope of determination of roadway capacity can be simplified for rural areas (Urbanik, 2000).

The emergency plans should include a map within the network of roadways in the region marking the main routes to be used during evacuation operations (Figure 2). This map may not include side streets to be used for access to the main roads to be used during evacuation to prevent the map from becoming too complicated. Numbering and marking each section of the

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highways network and important junctions will facilitate the use of the map. The sub-areas used to generate demand estimates should also be shown on the map (U.S. NRC, 2011).

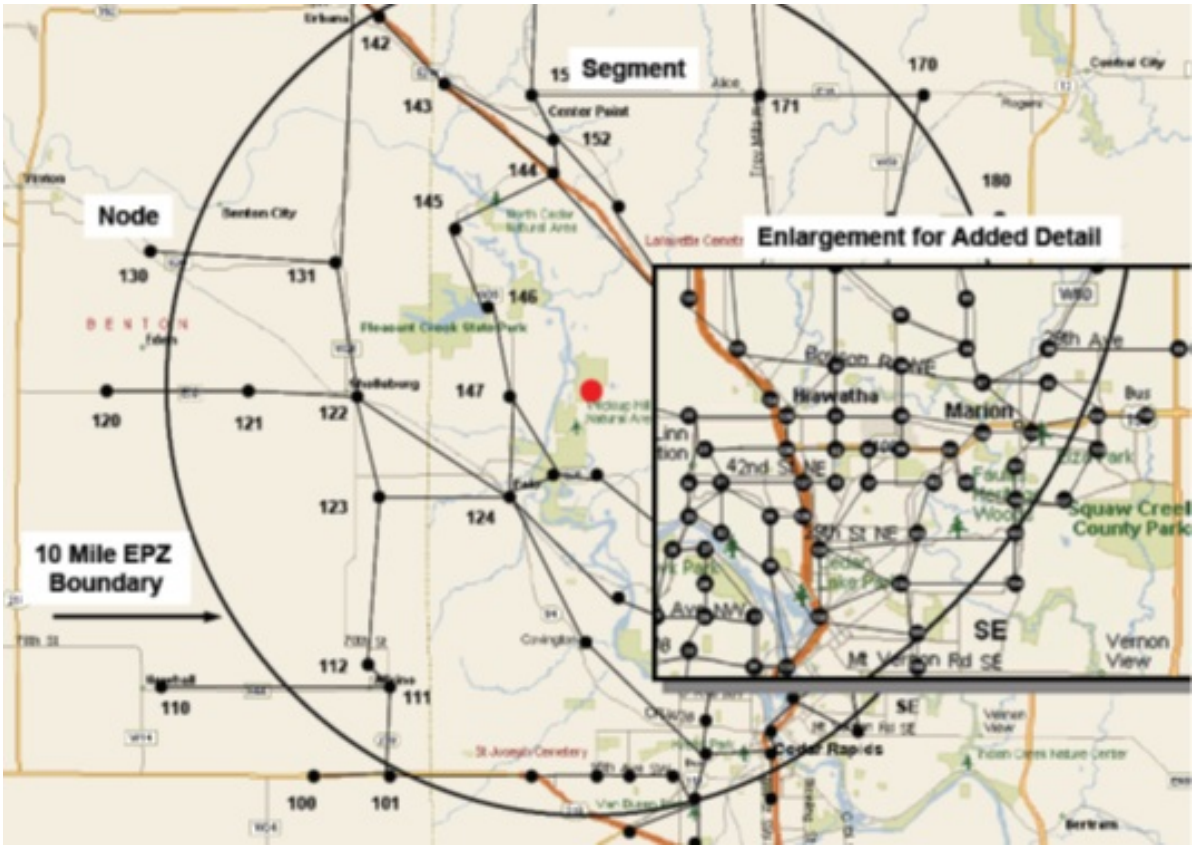

Figure 2. Sample Roadway Network Map Identifying Nodes and Segments (U.S. NRC, 2011)

The characteristics of the highways on all routes to be used during the evacuation should also be presented in this section. The basic information to be given in this context is listed below (U.S. NRC, 1980):

- Number of lanes of the roads
- Width of lanes
- Areas where slope changes on roads more than 4%
- Left turns in lane group
- Right turns in lane group
- Areas where roads are most narrowed
- Areas with roundabouts
- Areas with motorway toll booths
- Waiting capacities at intersections
- Speed limits
- Areas where there is a risk of flooding, landslides or avalanches on roadways
- Damaged surfaces on roadways

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3.3 Analyses for the determination of evacuation time estimate

Scenarios drawing up the time and the conditions of the evacuation should be prepared and all analyses should be performed considering both the most appropriate and the worst conditions during the determination of the evacuation time estimate. When creating scenarios for evacuation, situations representing summer and winter as season, weekday or weekend as day, daytime or night as time, normal or unfavorable situations as weather conditions which covers appropriate and bad situations should be created. The weather conditions under which the evacuation is foreseen to be implemented should be selected considering the climatic conditions of the region. All conditions specified in the scenarios will affect the average travel time and the number of people to be evacuated. Adverse weather conditions may increase travel times, the evacuation at the weekend may reduce the number of people to be evacuated due to the absence of employees in institutions and establishments in the region and at summer times the number of tourists in the region will be higher and so the number of evacuees will also be higher. During the determination of scenarios, it should be taken into consideration that more than one negative condition may exist at the same time while creating combinations of conditions (Conlow, 2008).

There are two basic approaches that can be used in the analysis of the evacuation time estimate. The first approach assumes that all evacuation events proceed sequentially (initiation of evacuation after everyone has been notified and completed their preparations for evacuation, movement of all vehicles, etc.). In this approach, the estimated total evacuation time is calculated by adding together the maximum times (the highest of the determined times taking into account different scenarios) for each population group or sub-area, but this may in general lead to a much higher estimate of the evacuation time. The second approach is the use of more complex and near-realistic assumptions. This approach takes into account the distribution functions for each population group or sub-area (such as the different distribution functions for each group to be notified of the emergency or evacuation action, for persons to be evacuated from their home or workplace, for the ones that use their own vehicle or public transport) and these functions are analyzed in a combined manner to determine the total evacuation time. With the second approach, shorter and more realistic evacuation times can be determined than the first approach.

The possibilities for ending each stage of the evacuation operations at the specified times are determined when the distribution functions are used during the estimation of the evacuation time. These conditional possibilities for each stage depend on the completion of the preceding stage (such as that families or tourist groups living in the area cannot start their preparations for evacuation without receiving information or instructions). The combination of distribution functions is considered to be “S” shaped evacuation time curves for each population group (Figure 3), and the total evacuation time can be determined as the time when all persons in all population groups in the region are evacuated (U.S. NRC, 1980).

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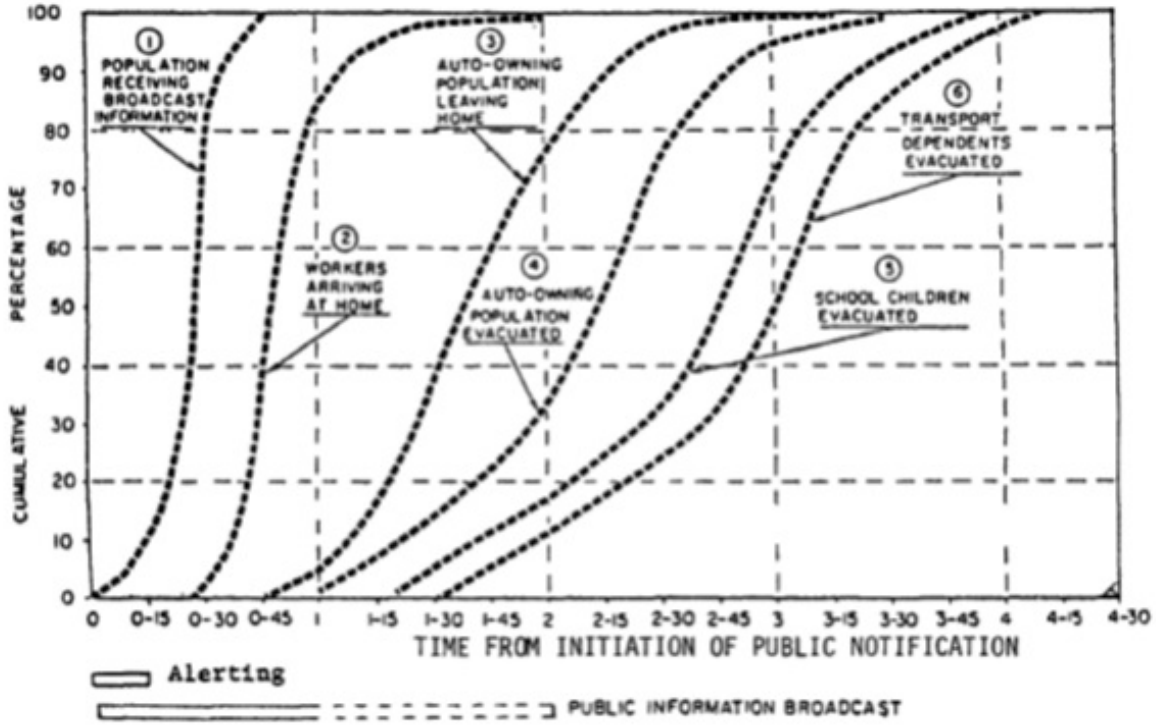

Figure 3. An Example of Evacuation Time Curves Using Distribution Functions (U.S. NRC, 1980)

4. Current Situation for Turkey in Terms of Evacuation Planning, Preparedness for Evacuation and Evacuation Time Estimate Studies for Nuclear Power Plant Emergencies

When the current regulations and plans of Turkey about the evacuation planning, implementation of evacuation actions and evacuation time estimate studies during nuclear power plant emergencies are examined, it is seen that The Regulation on Nuclear Power Plant Sites (21.03.2009 dated and 27176 numbered Official Gazette) states that during the evaluation of the suitability of a site for the construction of a nuclear power plant the applicability of the emergency measures should be taken into account. According to this regulation, in order to demonstrate the applicability of the evacuation action, which is one of the emergency measures, information on population density and distribution in the region and other site characteristics shall be taken into consideration. Similarly, The Regulation on Special Principles for the Safety of Nuclear Power Plants (17.10.2008 dated and 27027 numbered Official Gazette) states that the applicability of emergency measures such as evacuation should be documented to limit the off-site radiological effects of radioactive substances that may be released during emergencies. The information to be provided in the site report to be prepared for the nuclear power plants in the Site Report Form and Content Guide for Nuclear Power Plants, which are formed on the basis of these regulations, included transportation infrastructure in the region, population distribution in the region, and distribution of population groups requiring special measures for evacuation in the region. It is considered that the collection of this information on the siting stage within the scope of the licensing of nuclear power plants is important for the use of these information during the preparation of the evacuation plans for emergencies.

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In The Regulation on Disaster and Emergency Response Services (18.12.2013 dated and 28855 numbered Official Gazette), a framework has been drawn for the planning of disaster and emergency situations including nuclear power plant emergencies and the duties and responsibilities of the institutions regarding response services have been defined. It is stated that the plans that will be created in this context are Turkey Disaster Response Plan (TDRP) (03.01.2014 dated and 28871 numbered Official Gazette) and the national level service group's plans at the national level and provincial disaster response plans and local level service groups' plans at the local level. Evacuation planning for disasters and emergencies is also considered to be part of or compatible with national and local level plans. The main responsibility for the evacuation actions to be implemented during disaster and emergency situations is given to Evacuation and Housing Planning Services Group, which is leaded by the Ministry of Interior, in the TDRP. Responsibility for evacuation actions during nuclear power plant emergencies is given to the relevant service group at the national level and to the Governorate of the province where the nuclear power plant is located at the local level in the National Radiation Emergency Plan (NREP) (06.04.2019 dated Presidency Approval) which is prepared on the basis of TDRP and Disaster and Emergency Response Services Regulation. NREP also describes the emergency planning zones for the nuclear power plants. The Precautionary Action Zone and Urgent Protective Action Planning Zone are determined in NREP to ensure that effective protective actions and other response actions can be promptly implemented to protect the public during emergency situations. The most important protective action to be implemented during an emergency within these zones is the evacuation.

In this case, the evacuation planning for the emergency planning zones of the nuclear power plant and, if necessary, planning for the evacuation activities to be carried out outside these regions should be made by the Governorship of the province where the power plant is located within the scope of the Provincial Radiation Emergency Plan. When the existing legislation and plans are examined, it is seen that these documents do not contain detailed provisions regarding the scope and content of evacuation plans. Therefore, it is considered that the issues in section 2 of this study should be taken into consideration when determining the scope of evacuation plans. It was evaluated that the information on the evacuation planning issues can be obtained from the site report prepared for the nuclear power plant. However, considering the provisions in section 3 of this study, it may be insufficient to provide detailed information about the transportation infrastructure from the site report and acquiring detailed information from the Ministry of Transport and Infrastructure and the General Directorate of Highways should be considered.

The analyses related to the determination of the evacuation time can be carried out within the scope of evacuation plans to be made by the Governorate or it might be more appropriate to carry out these analyses by the nuclear power plant operators at the licensing stage. These analyses will be crucial in determining the time available for the mitigation actions to be taken after the operator declares an emergency. The databases of Turkish Statistical Institute should be used during the determination of demand estimates for evacuation time estimate studies. During the determination of the permanent population in the region for Turkey, Turkish Statistical Institute's (TÜİK) Address Based Population Registration System (ADKNS) database should be used. During the determination of the temporary persons in the nuclear power plant region for Turkey, the relevant databases of TÜİK (the number of tourists and migrants visiting the region) and the information about the number of persons employed by the institutions and organizations in the region should be used. During the determination of the roadway capacities, the information collected within the scope of the evacuation plans

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should be compiled and used in accordance with the requirements of the highways characteristics listed in section 3.2 of this study.

It is considered that the assumptions which will be made within the scope of evacuation planning and evacuation time estimate studies should take both the information specific to the region as explained below and other factors that can affect the evacuation actions and that are specific to Turkey into account. When the nuclear power plants to be built up in Turkey and the nuclear power plants which are close to the borders and some regions of their emergency planning zones are within the lands of Turkey are considered, the important factors are thought to be special locations of the highly populated residential areas in the emergency planning zones, high number of settlements in the rural areas of the emergency planning zones, the nomadic people and livestock belonging to residents of the emergency planning zones.

The most critical example regarding the special locations of the residential areas is that the Sinop province center is located within the Urgent Protective Action Planning Zone of the nuclear power plant planned to be built in the region. Since it is located on a peninsula, Sinop city center has limited accessibility and it is likely that evacuation actions will be slow and distressed during an emergency. The best example for the situation of the high number of settlements in the rural areas and livestock belonging to residents of the region is thought to be Iğdır province. Some border villages of Iğdır remain within the emergency planning zone of the Metsamor Nuclear Power Plant in Armenia. Different ethnic groups live in these border villages and the main livelihood of these villages is animal husbandry. During the exercises held in the region, it was noteworthy that people living in these border villages were not very keen to follow the instructions of the authorities. In addition, it is observed that the livestock population in these villages is much more than the human population and the people living in the villages tend to implement evacuation actions only with the condition that their animals are also evacuated. These issues are considered to be of great importance for evacuation planning for the region. Considering the issue of nomads living in Turkey, they are more intensively present in the Mediterranean region and it is thought that the evacuation planning studies which are performed for the nuclear power plant in the Mersin province should take into account these groups. It is considered that during the implementation of evacuation actions, the special situations of nomads should be taken into consideration in order to give instructions to the public, to provide information and even to carry out the actions smoothly.

5. Conclusions

In this study, the issues that need to be emphasized during the evacuation planning and estimation of evacuation time and the methods to be used during the analysis to estimate the evacuation time are explained. The information about the contents of the presentations of these studies in the emergency plans are given together with the basic assumptions on the subject. These explanations were generally made by examining the regulatory and technical documents together with scientific papers about the subject. Moreover, the current situation in Turkey in terms of evacuation planning and evacuation time estimate studies is summarized together with the examples of important specific factors that can affect the planning and implementation of evacuation actions during nuclear power plant emergencies.

The best strategy that can be applied to avoid high radiation exposures during nuclear power plant emergencies is to evacuate the area when the conditions are safe before the release of radioactive materials. In this context, as the population to be evacuated increases, in advance planning becomes more important. The roads, vehicles and spaces that meet the need under normal conditions may be insufficient in such a mass population movement. Road densities

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might reach values they have never reached. For this reason, very low driving speeds are taken into account when calculating evacuation times. The extent to which the public is prepared for evacuation and the degree of adherence to evacuation routes is the most decisive factor for the evacuation by reducing negative impacts. Another decisive factor is weather conditions. Therefore, scenarios developed for different weather conditions should be taken into consideration in case of disruptions due to extraordinary weather conditions. It is seen that the above mentioned issues are taken into consideration in the evacuation planning sections of the documents examined within the scope of the study. However, these documents did not take the difficulties of public communication, confusion during emergency conditions and other the challenges of evacuation into much consideration. These problems may be specific to the country or region where the nuclear power plant is located.

When an individual is evacuated, the first thing he or she thinks of is to get together with family members. Therefore, it may be a significant waste of time for family members to come together. It should not be underestimated that even those who want to get together with family members will significantly reduce the capacity on the roads on the evacuation routes, and that problems may occur during regular evacuation. Depending on the socio-economic and cultural structure of the society or due to individual concerns, individuals may refuse to be evacuated, in which case the emergency staff assigned to perform the evacuation may face serious problems.

It is considered that the information that should be used in the documents related to the generation of the demand estimates and the roadway capacity which are the studies carried out within the scope of the analyses regarding the estimation of the evacuation time, should be determined by considering the factors that increase and decrease the effectiveness of evacuation actions. Public awareness, public information about alarm signals, diversification of communication channels, effective coordination and cooperation of evacuated persons are among the factors that increase the effectiveness of evacuation action. Traffic accidents, traffic jams, deaths from the hazard itself, evacuation injuries, shadow evacuations, refusal to accept evacuation and violent movements should be considered among the factors that reduce the effectiveness of evacuation. When estimating evacuation times, it should be noted that all these factors are specific to the area where the evacuation will take place. The important factors that are specific to Turkey in terms of evacuation planning are considered as special locations of the highly populated residential areas in the emergency planning zones, high number of settlements in the rural areas of the emergency planning zones, the nomadic people and livestock belonging to residents of the emergency planning zones.

As a result, resources should be analyzed correctly and any problems that may occur during evacuation should be evaluated together with alternative solutions during evacuation planning. The analysis to estimate the evacuation times can be carried out in a more realistic way by gathering the detailed and correct information from the related reports such as site report for nuclear power plants and related institutions such as TÜİK and General Directorate of Highways and taking into account the factors specific to the country or region in this manner.

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