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Empirical Risk Estimation for the Transport of Radioactive Wastes

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1. Introduction

The transport of radioactive wastes may cause radiological risks to the general public as well as workers. Therefore, a specific safety level during the transport of radioactive wastes has to be assured in terms of a proper design of the packaging, a radiation protection, and an environmental protection. In this study, the empirical risks resulting from the transport of radioactive materials were estimated and compared.

2. Transportation Risks

Risks for a radioactive waste transportation arise from both conventional vehicular accidents and exposures to a ionizing radiation under both normal and accident conditions. Transportation risk includes health and safety risks that arise from the exposures of workers and members of the public to a radiation from shipments of wastes. It also includes social risks that arise from social processes and the peoples' perception, even in the absence of radiation exposures[1].

The health and safety risks arise from exposures of people who travel, work, or live near transportation routes and transportation workers themselves to a radiation from radioactive waste packages. Although the radiation doses to individuals near transport routes are likely to be very small, large numbers of individuals may receive exposures, producing a collective dose that can be used to estimate health impacts. Health and safety risks are frequently characterized in terms of human health effects such as injuries and a loss of human life.

Social risks can have both direct socioeconomic and perception-based impacts such as an increased stress and anxiety, loss of sense of security and safety, loss of trust and confidence in government and government agencies, reduced desirability as a place to live, reduced economic activity, and reduced property values, and so on. However, the social risks are harder to measure than the health and safety risks, and even identifying the cause-and-effect relationships can be difficult.

The health and safety risks and social risks can have significant interactions. Increases in radiation exposures or in the incidence of health effects from transportation operations may, over time, increase the perception-based impacts. On the other hand, transportation operations that are carried out without demonstrable health impacts may, over time, reduce the perception-based impacts.

There is another class of non-radiological impacts, i.e., conventional vehicular impacts associated with the transportation of radioactive wastes. These include the health impacts of exhaust emissions from transport conveyances and vehicular accidents that result in fatalities, injuries, and property damage.

3. Empirical Risk Estimation

There is no centralized database for the worldwide shipment of radioactive materials. However, the IAEA has been collecting such data at the recommendation of its transportation advisory committee since 1980. Also, the Unites States collected a database for shipping accidents and incidents. Based on the 1971-1990 accident data, DOE calculated accident and incident rates for waste shipments to a repository. DOE calculated 0.7 accidents per million shipment miles for truck shipments and 9.7 accidents per million shipment miles for rail shipments. Based on the comparison between these accident and incident rates and the general accident rates for large commercial truck and general freight movements, DOE recommended the use of a truck accident rate of 0.7-3.0 accidents per million shipment miles and a rail accident rate of 11.9 accidents per million shipment miles[2].

We estimated the shipment distances for the transport of low and intermediate level radioactive wastes in the interim storage facility of four nuclear power plant sites to the disposal site, Gyoungjoo. We assumed that the transport mode is road and the transport begins in 2009 and it will end in 2060. The data for the calculation of the total shipment distances are summarized in Table 1[3]. The total distance is 771,561 km, i.e., 482,225 miles. If we use DOE's recommendation for the accident occurrence rate, the accident rate is 0.33-1.44 accidents per million shipment miles.

Table 1. Data for the total shipment distances

Site / Parameters	KORI	WS	YGN	UCN	MISC
Transport distance (km)	84.6	6	410.6	194.7	270.7
Number of shipment	1020	715	714	1191	576
Total distance (km)	86292	4290	293168	231888	155923

During a normal transport of radioactive wastes, individuals who travel, work, and live along the routes

used for shipping radioactive wastes might receive small radiation doses. The dose comparison is very useful for an understanding of the transport safety of radioactive wastes. The graphical illustration of the radiation dose comparisons is shown in Fig. 1[1]. The maximally exposed service station worker could receive a dose of about 1.0 mSv which is dose limits to the members of the public. Also, the maximally exposed resident near a rail stop and a resident near a rail route would receive about 0.12 mSv and 0.0007 mSv, respectively. All these values are below the limits to the members of the public.

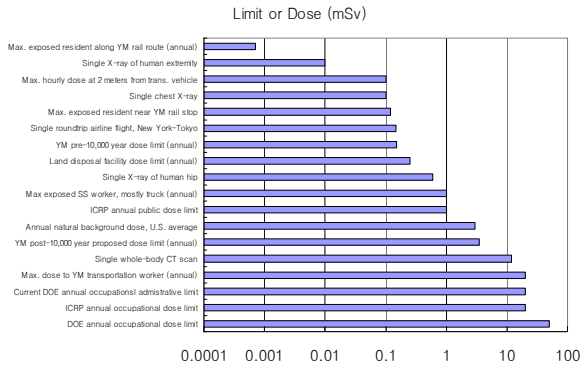

Figure 1. The radiation dose comparisons

If an extreme accident occurs during the transport of radioactive wastes, workers and the general public may be exposed to a radiation. According to the final Yucca Mountain EIS statements[4], the probability of such an accident is very low; 2.3 in 10 million per year for trucks and 2.8 in 10 million per year for trains. The comparison of the potential consequences of such extreme accidents involving spent fuel and high-level wastes with those for other hazardous materials transport is also very useful for an understanding of the transport safety of the radioactive wastes. The expected fatalities from hypothesized accidents during a transport of three types of hazardous materials and spent fuel in the form of complementary cumulative distribution functions (CCDF) is shown in Figure 2[1]. The vertical axis is the probability per year by assuming 100 shipments. As shown in Figure 2, the probability for the spent fuel is much lower than that for the other hazardous material transports.

4. Conclusion

From the review of other studies and an empirical risk estimation of the transport of radioactive wastes, the transport of radioactive wastes is a low radiological risk activity with a manageable safety, health, and environmental consequence. However, there may be a number of social and institutional challenges to the successful transport of radioactive wastes from the nuclear power plant to a repository. Therefore, detailed and sophisticated transport risk assessment and management must be made. That is, the principal risks and the principal technical and social concerns for transporting radioactive wastes are to be determined. The transportation planners and managers should undertake detailed surveys of transport routes to identify potential hazards and they should also take steps to avoid or mitigate such hazards before the commencement of shipments. The available options involving changes to planned transportation routes, modes, procedures must be evaluated. Also, options for improving the communication of the transportation risks to decision makers and the general public must be estimated and compared for the sate transport of radioactive wastes.

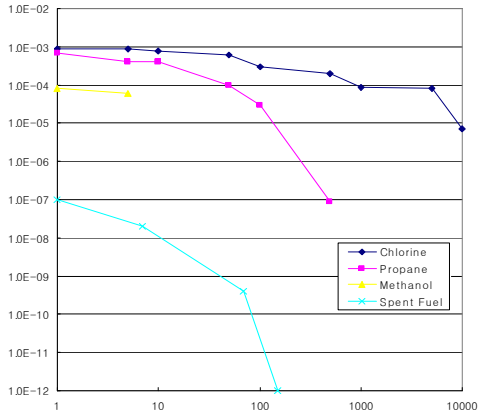

Figure 2. CCDF's showing expected fatalities for hypothesized accidents during transport

Acknowledgement

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