Briefing Note
Radiation Exposure During the Transport of Nuclear Waste

Summarized from "Radiation Exposures From Spent Nuclear Fuel and High-Level Nuclear Waste Transportation to a Geologic Repository or Interim Storage Facility in Nevada", by Robert J. Halstead

Measuring Radiation Exposure

Exposure to radiation is measured in "rem" or "millirem" (one thousand millirem equals one rem). In the United States, average background radiation is estimated to be 360 millirem (mrem), with 200 millirem from radon gas, which is a natural source, and 40 millirem from medical x-rays, one of several human-made sources. By comparison, the dose from one chest x-ray is approximately 10 millirem. Regulatory agencies in both the U.S. and Canada have set limits for worker exposure which are considerably higher than the level of natural background radiation. In the U.S., the annual dose limit for radiological workers is 5,000 millirem (the limit for a pregnant worker is 500), while the dose to the public from nuclear industries is limited to 100. The U.S. Nuclear Regulatory Limit has published estimates that a whole body dose of 25,000 mrem poses a significant risk of serious health effects and a whole body does of 500,000 mrem is a probable cause of death. Government regulations also require that the nuclear industry follow a radiation control concept known as "ALARA" or "As Low As Reasonably Achievable". The ALARA objective is to keep worker and public doses as low as possible. It must be noted that there is considerable technical controversy about individual health effects of any additional exposures above background levels, with a large body of thought subscribing to the view that there is no acceptable level of radiation exposure above background.

Exposure Due to Transportation of Nuclear Fuel Waste

Increased level of radiation exposure due to the transportation of nuclear fuel waste can be generally grouped into three categories: routine transportation operations; accidents including severe accidents during transportation or transfer; and terrorist attack during transportation, with possible catastrophic results.

Routine Transportation Operations

During routine transportation operations, radiation is continuously emitted through cask walls. In the U.S., the Nuclear Regulatory Commission has set an exposure limit of 10 mrem per hour at 2 metres from the cask surface, or the equivalent of one chest x-ray per hour of exposure. Three different scenarios must be considered for routine operations: members of the public residing or working at locations near shipping routes; vehicle occupants trapped in traffic gridlocks; and worker exposure during transport (ie. drivers) or inspection.

According to studies cited by the State of Nevada (concerned about exposure during transportation of waste to the proposed site at Yucca Mountain) individuals who reside, work, or are institutionally confined at locations within 6 to 40 meters of a nuclear waste highway route, or within 6 to 50 meters of a nuclear waste rail route, could potentially receive yearly radiation doses equal to, or even in excess of, average annual background doses.

The Sandquist report, prepared for the U.S. Department of Energy, calculated maximum individual exposures (in millirems) per event to estimate maximum potential annual doses to individuals near truck cask shipping routes. Depending upon the number of truck shipments and distance from the route, maximally exposed individuals near highway routes could potentially receive annual doses ranging from 6 mrem to 960 mrem, equivalent to 2% to 266% of the average annual background radiation dose.

Estimation of exposures from rail transportation is more difficult, primarily because of uncertainties about service options (dedicated trains versus general freight service), number of casks per shipment, and continuous rail shipment or intermodal transfer. Maximally exposed individuals located within 20 meters of rail interchange/transfer points could potentially receive annual doses in the range of 150 mrem, assuming 500 rail cask/shipments per year and an average exposure time of 10 minutes per rail cask received.

Drivers and passengers of vehicles in traffic gridlock incidents could receive potentially significant radiation doses as a result of being trapped next to or near an undamaged truck cask for an extended period of time. Occupants of stopped vehicles in lanes adjacent to the cask vehicle could receive a maximum dose of 3 mrem, assuming a distance of 5 meters from the cask center and an exposure time of 30 minutes. The maximum dose from a gridlock incident could be as high as 40 mrem. It should be noted that one individual could be exposed in this way on more than one occasion, particularly if they are regular commuters along waste transport routes.

Workers responsible for safety inspections could receive yearly occupational doses significantly in excess of annual background doses. With each truck cask inspection estimated to take about 12 minutes , at a distance of 3 meters from the cask center (near the personnel barrier), and result in a dose of 2 mrem per event. An inspector could receive an annual dose of up to 2,500 mrem.

Accidents During Transportation

In severe transportation accidents the cask radiation shielding could be damaged, resulting in elevated gamma and neutron radiation levels around the damaged cask and possibly in the release of some portion of cask contents which would result in the contamination of a relatively large down-wind area with alpha-, beta- and gamma-emitting isotopes (There are three types of radiation from nuclear materials: alpha, beta and gamma).

Studies relied upon by the State of Nevada examined three types of severe accidents. While design details are not available for the proposed shipments to a Canadian repository, the cask design and net source term assumptions have been deemed reasonably close to what is currently expected for shipments to a repository or interim storage facility by the State of Nevada, ie to the proposed Yucca Mountain repository.

The most severe accident scenario analysed in the Sandquist study involves a high-speed impact followed by a long duration, high temperature fire fed by some external source of petroleum fuel with a total release of about 6,159 curies. The most exposed individuals would receives an estimated dose of about 10.2 rem, primarily from inhalation of radionuclides (eg. an emergency responder located 70 meters directly downwind from the point of release for a period of "a few hours". The radionuclides released by the accident are carried downwind (in the plume of smoke from a petroleum fire) and contaminate an area of about 110 square kilometers (42.5 square miles). The release from the worst case rail accident in a typical urban area results in "22 latent health effects"[about half cancers, and half genetic disorders]. Cleanup of the contaminated area, assuming that the accident occurs in a rural area, could cost as much as $620 million (1985$) and require 460 days. In an urban area, the cleanup cost is estimated to exceed $2 billion.

A review by the State of the Nevada indicates that the Sandquist report, first published in 1985, is still the best available reference for estimating exposures from severe spent nuclear fuel transportation accidents. However, it notes that there are some deficiencies in Sandquist's report including:

C there is potentially too great a reliance on expert opinion versus empirical evidence

C the report underestimates the potential for severe rail accidents in highly-populated places

C the methodology used to calculate population-dose estimates and the resulting health effects is grossly superficial

C Gamma and neutron radiation emitted from the cask as a result of shielding loss is not considered

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Source: “Radiation Exposures From Spent Nuclear Fuel and High-Level Nuclear Waste Transportation to a Geologic Repository or Interim Storage Facility in Nevada”, by Robert J. Halstead. Provided by the State of Nevada Nuclear Waste Project Office. Available at http://www.state.nv.us/nucwaste/trans/radexp.htm

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