Radiation Hazards Analysis in Transport of Low Specific Activity Waste Material

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An analysis of potential radiation hazards from transporting low specific activity (LSA) waste materials was carried out in support of an effort to evaluate the implications of proposed changes in regulations that govern such activities. The approach in this work was to assess the hazards to cleanup personnel and members of the general public from various transportation accident scenarios that involve the dispersion of LSA materials. Although wastes currently transported are relatively innocuous, those permitted under current and proposed regulations could present hazards under worst-case scenario assumptions. A probabilistic approach to future efforts is recommended.

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SURVEY OF LSA SHIPMENTS

Data were collected on LSA shipments during 1980 for radioactive ores and for LSA waste (2). Data on waste shipments were collected from the three commercial waste disposal sites in the United States. These data were analyzed to characterize LSA shipments in terms of general material description, container type, activity level, and radionuclides present. The most significant results of this survey of LSA shipments are as follows:

1. Of the 85 000 curies (Ci) shipped annually as LSA materials, most (81 000 Ci) are shipped as LSA waste;
2. Virtually all LSA shipments are made by truck;
3. The average concentration is 0.004 mCi/g, much less than the 0.3 mCi/g permitted under present regulations for other than transport group 1 radionuclides;
4. More than 80 percent of the packages shipped are 55-gal drums, but they contain only 15 percent of the total activity shipped; and
5. Large liners ($\geq$100 ft^3) that carry cobalt 60 and cesium 137 in solidified cement and resin shipped to the waste disposal site at Barnwell, South Carolina, make up only 3 percent of the total number of packages, but they contain 50 percent of the total activity.

BASIC RADIATION HAZARDS

Four mechanisms of radiation exposure were considered in this study:

1. Gamma radiation to the external body,
2. Internal radiation by ingestion,
3. Internal radiation by inhalation, and
4. Beta radiation to the skin.

For each mechanism, potential hazards were analyzed for single-container and partial-truckload spills of LSA materials, both at existing (3) and proposed (4) maximum permitted concentrations and from actual average and maximum concentrations. Actual concentrations shipped were determined from the survey of LSA shipments. Hazards to cleanup workers and the general public were considered.

For external gamma radiation the calculations support the conclusion that a spill of LSA material that contains radioactivity at the current maximum theoretical concentrations (0.3 mCi/g) could be hazardous to both workers and the general public. In particular, members of the general public could receive a maximum annual dose in minutes if they were at the edge of the spilled material. Since the proposed regulations would generally permit greater concentrations of radioactivity to be shipped as LSA, the same or greater potential external gamma hazards would exist. For accidents that involve average and maximum actual shipments of LSA, workers are unlikely to be overexposed as long as some caution is used. Further, members of the general public are adequately protected by a 10-m buffer distance for the case of a single-package accident and a 100-m buffer distance for the more serious partial-truckload spill. The exclusion of spent resins from the actual shipments at maximum concentrations results in a significant reduction in potential external gamma radiation hazard. For members of the general public, the buffer distances would be reduced to 1 m for single-package spills and 10 m for partial-truckload spills.

Ingestion of most radionuclides would not result in overexposure for emergency workers or for members of the public for LSA shipments at the theoretically allowable maximum concentrations permitted under existing regulations. The proposed regulations could allow overexposure to workers from the ingestion of eight radionuclides: sulfur 35, calcium 45, nickel 63, strontium 89, iodine 126, praseodymium 143, mercury 203, and radium 226. Because none of these radionuclides is a major component of the total activity actually shipped and because the assumed hazard could be eliminated through reduced concentrations or longer storage time for all but Ra-226, we believe these exceptions are not of great enough significance to warrant special concern. The same conclusions apply to members of the public if we assume that they would ingest no more than 1 mg of LSA (as compared with the assumption of 10 mg ingested by cleanup workers).

For inhalation of LSA material, the degree of hazard depends greatly on the particle size of the material. The controlling parameter is the upper limit of the range of particle size. Particles that have a maximum diameter significantly smaller than 50 μm are not likely to be inhaled in significant amounts. Inhalation doses for emergency workers and members of the public were found to be well below routine exposure guidelines for these average LSA compositions. The only event that would produce doses greater than annual background doses is the spill of a partial truckload of material at maximum permitted concentrations.

Calculation of downwind population doses from accidents involving actual waste compositions indicates a population dose equivalent to 15 percent of the annual background dose for the 7900 people in a downwind sector as a result of a partial-truckload accident of maximum actual composition LSA. Radiation doses to the skin from beta-emitting nuclides were calculated for each scenario and waste composition. For the average and maximum actual compositions, beta skin exposure is not a significant problem.

For maximum theoretical shipment of LSA under the present regulations, skin doses as high as 20 rad to the emergency worker could result from the partial-truckload accident. Although this does not exceed recommended emergency dose limits, the doses under the proposed regulations could be higher. Skin deposition is a more significant problem for emergency workers than for members of the general public.

CONCLUSIONS AND RECOMMENDATIONS

The primary potential hazard of concern would be the external gamma radiation from shipments near the maximum permitted concentrations. In actual shipments, concentrations approach maximum permitted levels only for spent resins and materials solidified in cement. If these materials are excluded from the LSA category, this potential hazard is not excessive.

The foregoing analyses have considered the potential hazards due to theoretical maximum shipment accidents under current and proposed regulations, as well as the hazards of typical and maximum actual shipments that might be better indicators of the range of likely hazards given an accident involving a shipment of LSA. By studying the survey of materials currently shipped we can determine whether current regulations or generator practice limits shipping activities. We suspect that generator practice limits shipping activity because few shipments even approach the permitted maximum.

If such is the case, the proposed changes in the regulations would allow increased flexibility of operations without materially affecting public safety. Isolated shipments that have one isotope at a higher activity than now permitted would not result in a significant increase in the average activity per shipment. On the other hand, if the shipment activity were regulation limited, a change in regulations could affect the actual hazards of shipment of LSA significantly.

As a more general comment on hazard assessments, we would suggest the use of the probabilistic approach in future efforts. It is possible to postulate hazardous situations under either the present or proposed regulations for transport of LSA. It would be appropriate, however, to temper these conclusions with information on the likelihood of such unusual events. This is the basis of probabilistic risk assessment, a tool that would be applied beneficially to such efforts in support of regulatory decisions.

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Aerometric Instrumentation for Real-Time Monitoring at Hazardous Spill Sites: Overview of Needs and Resources

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The last decade has seen a fourfold increase in the number of casualties from transportation incidents involving hazardous materials. Responder groups often cannot manage such incidents effectively because they lack knowledge of the chemicals involved, the peak concentrations present in the atmosphere, or the spatial extent of the hazardous zone. A systematic approach to providing responder groups with appropriate instrumentation needs to be developed. An introduction to the categorization of user needs is presented in terms of four types of constraints: time available for response, nature of the spill and the chemicals involved, responder expertise, and spatial extent of the impacted area. An overview is also provided of the general classes of instrumentation that should be considered.

Over the past decade, there has been a fourfold increase in the number of casualties from transportation incidents involving hazardous materials. In turn, the number of reported incidents over the same period has increased about eightfold (perhaps partly the result of stricter reporting pressures). Figure 1 illustrates the increases in incidents and casualties according to mode--(a) highway and rail and (b) air and water. Figure 2 provides corresponding information on the distribution of the hazardous materials (a) involved in the incidents and (b) responsible for the associated fatalities, respectively.

The distribution and concentration of toxic and hazardous substances in the air (and, correspondingly, the dangers) at a spill site are often poorly understood or simply unknown. The many possible reasons include the following--the identity of the chemicals is often unknown, in one-third of all railroad incidents it was impossible to read the placard on the car, and manifests could not be obtained for one-half of these incidents. Even if the chemicals are known, instruments to detect them in the field at the concentrations present may not exist or may be unavailable to the responders. In