Appendix M

Supplemental Transportation Information

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APPENDIX M. SUPPLEMENTAL TRANSPORTATION INFORMATION

Radioactive materials are in common use in the United States for a wide range of purposes, including medical applications, precision instrumentation, and home products such as smoke detectors. Shipments of these materials occur throughout the country every day. A variety of regulations govern these shipments to ensure safety. Of the estimated 3 million annual radioactive material shipments, most involve low-level materials. Of the more than 2,700 shipments of commercial spent nuclear fuel completed over the past 30 years, none has resulted in an identified injury caused by the release of radioactive materials. While a repository would increase the total number of all radioactive materials shipments, spent nuclear fuel and high-level radioactive waste shipments would be a small fraction of the total. Furthermore, the number of shipments of radioactive materials is small in comparison to the 300 million annual shipments of hazardous materials.

The U.S. Department of Energy (DOE or the Department) developed this appendix to provide general background information on transportation-related topics not addressed in detail in Chapter 6 or Appendix J of this environmental impact statement (EIS). Although this information is not essential for analyzing potential impacts associated with transportation, DOE, in response to public comments on the Draft EIS, is including it to help the reader understand the regulatory framework and safety provisions associated with transporting spent nuclear fuel and high-level radioactive waste. This appendix describes the types of radioactive wastes commonly shipped by DOE and others and the relevant transportation requirements for each. In addition, it highlights the regulations developed by the U.S. Department of Transportation and the Nuclear Regulatory Commission to regulate virtually every aspect of the transportation of radioactive materials, including spent nuclear fuel and high-level radioactive waste. Further, it describes the transportation operations and requirements that would apply specifically to a Yucca Mountain Repository if it was recommended and approved. In that context, this appendix also discusses the safety and testing of transportation casks, emergency response in case of a transportation accident, physical protection of radioactive materials, and liability.

M.1 Spent Nuclear Fuel and Radioactive Wastes and General Transportation Requirements

Because the hazard levels of spent nuclear fuel, high-level radioactive waste, and other radioactive wastes vary, the transportation requirements for each also vary. This section describes spent nuclear fuel and other types of radioactive waste, and the general transportation requirements pertaining to each.

M.1.1 SPENT NUCLEAR FUEL

Spent nuclear fuel results from the production of electricity at nuclear powerplants or from the operation of other nuclear reactors, such as research reactors. Spent nuclear fuel is reactor fuel that has been withdrawn from a reactor following irradiation, the component elements of which have not been separated by reprocessing. It includes the following forms:

- Intact nondefective fuel assemblies
- Failed fuel assemblies in canisters
- Fuel assemblies in canisters
- Consolidated fuel rods in canisters
- Nonfuel assembly hardware inserted in pressurized-water reactor fuel assemblies
- Fuel channels attached to boiling-water reactor fuel assemblies
- Nonfuel assembly hardware and structural parts of assemblies resulting from consolidation in canisters

Any of the materials fitting this definition would be transported to a repository in shipping casks certified by the Nuclear Regulatory Commission under the regulations discussed in Section M.2.

M.1.2 HIGH-LEVEL RADIOACTIVE WASTE

High-level radioactive waste is a byproduct of the reprocessing of spent nuclear fuel. During reprocessing, spent nuclear fuel is separated into material to be reused, such as uranium and plutonium, and waste material for disposal. High-level waste includes liquid waste produced directly during reprocessing and solid material derived from such liquid waste that contains fission products in sufficient concentrations. Other highly radioactive wastes determined by the Nuclear Regulatory Commission to require permanent isolation can also be high-level waste. To date, there have been no such determinations. High-level waste would be transported in solid form to a repository in the same manner as spent nuclear fuel in accordance with the regulations discussed in Section M.2.

M.1.3 LOW-LEVEL RADIOACTIVE WASTE

Low-level radioactive waste is basically any radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, or byproduct materials, such as uranium mill tailings. It results from research, medical, and industrial processes that use radioactive materials. Commercial powerplant operations and defense-related activities, including weapons disassembly and cleanup of production sites, also produce low-level waste. In addition, repository operations, such as the decontamination of transportation casks and the decontamination and decommissioning of facilities after completion of operations, could generate low-level radioactive waste.

Low-level radioactive waste usually contains small amounts of short-lived radioactive material dispersed through large quantities of other material. It poses little transportation risk. Typically, such wastes consist of used protective clothing, rags, tools and equipment, used resins and residues, dirt, concrete, construction debris, and scrap metal. This waste is usually packaged in sturdy wooden or steel crates and steel drums for shipment. Because of its level of radioactivity, some types of low-level waste are transported in shielded Type B packages, which are certified by the Nuclear Regulatory Commission (see Section M.2.1). The Commission requires that all low-level waste be in solid form (free of liquids) before shipment to a disposal facility. The U.S. Department of Transportation requires carriers of low-level radioactive waste to use routes that minimize radiological risk [49 CFR 397.101(a)]. There are several sites across the United States for low-level radioactive waste disposal. Such waste would not be disposed of at Yucca Mountain.

Mixed waste contains both hazardous chemical components and radioactive components and is subject to the requirements of the Atomic Energy Act, as amended (42 U.S.C. 2011 *et seq.*) and the Resource Conservation and Recovery Act, as amended (42 U.S.C. 6901 *et seq.*). Most mixed waste is low-level; however, some transuranic waste is classified as mixed waste.

M.1.4 TRANSURANIC WASTE

Transuranic waste contains elements heavier than uranium, thus the name *trans-* (or beyond) *-uranic*. It results from both defense and nondefense production activities and includes contaminated protective clothing, tools, glassware, and equipment. Transuranic waste from defense production activities is disposed of at the Waste Isolation Pilot Plant in New Mexico. The transuranic waste category was established to separate long-lived, alpha-emitting radionuclides from the low-level radioactive waste stream. Thus, transuranic waste includes wastes contaminated with alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries per gram. Waste containing less than 100 nanocuries per gram of transuranic contamination is classified as low-level waste. The gross radiation levels of transuranic waste are much less than those of high-level radioactive wastes, which emit significant amounts of beta and gamma radiation.

There are two types of transuranic waste, based on the amount of radioactivity. These wastes are typically shipped in 208-liter (55-gallon) drums or metal boxes transported in Type B packages. Almost all transuranic waste is *contact-handled*, meaning that it can be handled safely without shielding other than the drum or box. A small portion of transuranic waste is *remote-handled*, which must be transported in shielded casks.

DOE transports transuranic waste to the Waste Isolation Pilot Plant in New Mexico in accordance with U.S. Department of Transportation and Nuclear Regulatory Commission requirements. This transportation follows protocols agreed to in *Memorandum of Agreement for Regional Protocol for the Safe Transport of Transuranic Waste to the Waste Isolation Pilot Plant* (DIRS 155717-O'Leary 1995, all). Although not every shipment is classified as a Highway Route-Controlled Quantity of Radioactive Material, DOE has stated that, as a matter of policy, all shipments to the Waste Isolation Pilot Plant will follow U.S. Department of Transportation routing requirements for Highway Route-Controlled Quantities (see Section M.2.). A Highway Route-Controlled Quantity of Radioactive Material is a quantity in a single shipment that exceeds the amount of radioactivity specified in 49 CFR 173.425 and 10 CFR 71, Appendix A, Table A2. Highway and rail shipments of spent nuclear fuel and high-level radioactive waste to a Yucca Mountain Repository, if approved, would meet the definition of Highway Route-Controlled Quantities of Radioactive Material.

M.2 Transportation Regulations

DOE shipments of spent nuclear fuel and high-level radioactive waste from reactors and DOE sites around the country to a repository at Yucca Mountain would comply with applicable Federal, Native American, state, and local government regulations. The U.S. Department of Transportation and the Nuclear Regulatory Commission share primary responsibility for regulating the safe transport of radioactive materials in the United States. These agencies have implemented regulations to govern the transportation of radioactive materials consistent with international transport safety standards.

The Hazardous Materials Transportation Act, as amended (49 U.S.C. 1801), directs the U.S. Department of Transportation to develop transportation safety standards for hazardous materials, including radioactive materials. Title 49 of the Code of Federal Regulations contains the standards and requirements for packaging, transporting, and handling radioactive materials for all modes of transportation.

The Nuclear Regulatory Commission regulates the transportation-related operations of its licensees, including commercial shippers of radioactive materials. It sets design and performance standards for packages that carry materials with higher levels of radioactivity (10 CFR). The Nuclear Waste Policy Act, as amended (NWPA; 42 U.S.C. 10101 *et seq.*), all shipments to Yucca Mountain would be made in Commission-certified packages and in accordance with Commission regulations on the advance notification of state and local governments (Section 180).

M.2.1 PACKAGING

Packages for radioactive materials that meet the standards required by U.S. Department of Transportation and Nuclear Regulatory Commission regulations (see Section M.4.1) are the primary means to protect people and the environment during the transportation of radioactive materials. The type of package required depends on the radiological hazard of the material being transported. Packages are selected based on activity, type, and form of the material to be shipped. There are four basic types of packages for transporting radioactive materials:

- *Excepted* packages are for materials with extremely low levels of radioactivity, such as instrumentation and smoke detectors.
- *Industrial* packages are for materials that present a limited hazard to the public, including contaminated equipment and radioactive waste solidified in materials such as concrete.
- *Type A* packages are for materials with higher concentrations of radioactivity, such as radiopharmaceuticals and low-level radioactive waste.
- *Type B* packages are for materials with radioactivity levels higher than those allowed in Type A packaging. Type B packages range from small containers of sealed radioactive sources to heavily shielded steel casks that sometimes weigh as much as 136 metric tons (150 tons). Examples of materials transported in Type B packages include spent nuclear fuel, high-level radioactive waste, and other materials with high concentrations of radioisotopes, such as cobalt sources.

Another option, the strong tight package, is available for some domestic shipments of radioactive materials. It is authorized only for domestic shipments of certain materials with low levels of radioactivity in a vehicle hired exclusively for their transport.

All spent nuclear fuel and high-level radioactive waste shipments to Yucca Mountain would be in the most rugged casks, Type B. The Nuclear Regulatory Commission regulates and certifies the design, manufacture, testing, and use of Type B packages under regulations contained in 10 CFR Part 71.

All radioactive materials must be properly packaged so that external radiation levels do not exceed regulatory limits. The packaging protects package handlers, transporters, and the public against receiving dose rates in excess of recognized safe limits. Regulations in 10 CFR 71.47 and 49 CFR 173.441 prescribe the external radiation standards for all packages. For shipments to the proposed repository, the radiation limits would be 10 millirem per hour at any point 2 meters (6.6 feet) from the outer edge of the truck trailer or railcar.

M.2.2 MARKING, LABELING, AND PLACARDING

U.S. Department of Transportation regulations require that shippers meet specific hazard communication requirements in marking and labeling packages that contain radioactive materials and other hazardous materials. Markings provide the proper shipping name, an emergency response identification number, the shipper's name and address, and other important information. Labels are placed on opposite sides of a package to identify the contents and radioactivity level.

The required label is determined by the type of material shipped and measured radiation levels of the package contents. Shippers of radioactive materials use one of three labels: Radioactive White I, Yellow II, or Yellow III. The use of a particular label is based on the radiation level at the surface of the package and the transport index, which is a dimensionless number placed on the label of a package to indicate the degree of control to be exercised by the carrier during shipment. It is determined in accordance with 49 CFR 172.403.

- A White I label is for a package with a surface radiation level less than or equal to 0.5 millirem per hour and a transport index of 0.

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- A Yellow II label is for a package with a surface radiation level greater than 0.5 millirem but less than or equal to 50 millirem per hour and a transport index of not more than 1.

- A Yellow III label is for packages that require the greatest degree of control by a carrier. These packages include ones in which:

  — The surface radiation level is greater than 50 millirem per hour but less than or equal to 200 millirem per hour, and the transport index is not greater than 10

  — The surface radiation level is between 200 and 1,000 millirem per hour or the transport index is greater than 10 (shipment must be by an exclusive use vehicle)

Almost all spent nuclear fuel and high-level radioactive waste shipments to Yucca Mountain would have Yellow III labels. Some shipments of irradiated reactor fuel components and empty shipping casks could have Yellow II labels.

In addition, vehicles transporting certain shipments of radioactive materials must have hazard communication placards displayed clearly on all four sides. Some shipments containing a high level of radioactivity, including spent nuclear fuel and high-level radioactive waste are, by regulation, *Highway Route-Controlled Quantities of Radioactive Materials* and must have the required "Radioactive" placard placed on a square white background with a black border.

The shipper and carrier are responsible for using the correct markings, labels, and placards. Compliance with the requirements is enforced by the U.S. Department of Transportation and, for licensees, can also be enforced by the Nuclear Regulatory Commission. Markings, labels, and placards identify the hazardous contents to emergency responders in the event of an accident.

M.2.3 SHIPPING PAPERS

The shipper prepares shipping papers and gives them to the carrier. These documents contain additional details about the cargo and include a signed certification that the material is properly classified and in proper condition for transport. For transport to the proposed repository at Yucca Mountain, commercial sites would present DOE with loaded shipping casks and a certification that the casks have been properly loaded, assembled, and inspected. For its licensees, which includes all commercial nuclear power reactors, the Nuclear Regulatory Commission can enforce U.S. Department of Transportation regulations regarding preparation and offering of shipments to carriers for transport.

Shipping papers also contain emergency information, including contacts and telephone numbers. Carriers must keep shipping papers readily available during transport for inspection by appropriate officials, such as state inspectors.

M.2.4 ROUTING

Motor carriers of Highway Route-Controlled Quantities of Radioactive Materials, such as spent nuclear fuel and high-level radioactive waste, are required to use *preferred routes* that reduce time in transit [49 CFR 397.101(b)]. A preferred route is an Interstate System highway (including beltways and bypasses) or an alternative route selected by a state routing authority in accordance with 49 CFR 397.103 using U.S. Department of Transportation *Guidelines for Selecting Preferred Highway Routes for Highway Route-Controlled Quantity Shipments of Radioactive Materials* (57 *FR* 44131; September 24, 1992) or an equivalent routing analysis that adequately considers overall risk to the public. Prior to the shipment of spent nuclear fuel, the shipper or carrier, as appropriate, must select routes and prepare a written plan for the Nuclear Regulatory Commission listing origin and destination of the shipment, scheduled route, all

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planned stops, estimated time of departure and arrival, and emergency telephone numbers. The Nuclear Regulatory Commission reviews and approves such routes.

Except for requirements contained in 10 CFR 73.37, there are no Federal regulations pertaining to rail routes for shipment of spent nuclear fuel or high-level radioactive waste. The shipper and railroad companies (carriers) determine rail routes based on best available route and track conditions, schedule efficiency, and cost effectiveness. The routes must be submitted in advance to the Nuclear Regulatory Commission for approval.

The U.S. Coast Guard has participated in establishing barge routes used for shipments from reactor sites. The names of the ports to be used must be submitted in advance to the Nuclear Regulatory Commission.

The EIS analysis used computer programs to select routes that are representative of routes that could be used to ship spent nuclear fuel and high-level radioactive waste to a Yucca Mountain repository. The computer programs applied the regulatory requirements and industry practices discussed in this appendix. If the repository was approved, actual shipment route selections would be submitted to the Nuclear Regulatory Commission for approval 1 or more years before shipments began. Section M.3.2.1.2 discusses route selection in greater detail.

M.2.5 PRIOR NOTIFICATION

Nuclear Regulatory Commission regulations (10 CFR Part 73) provide for written notice to governors or their designees in advance of irradiated reactor fuel through their states. Federal regulations allow states to release certain advance information to local officials on a need-to-know basis. As required by Section 180 of the NWPA, all shipments to a repository would comply with Commission regulations on advanced notification to state and local governments.

The Nuclear Regulatory Commission is in the process of changing the requirements so that Native American governments would be notified under the Commission's notification rule (64 *FR* 71331, December 21, 1999). Notification of shipments to a repository would be in accordance with Commission regulations in effect at that time.

M.2.6 TRAINING

U.S. Department of Transportation regulations (49 CFR Part 391) require anyone involved in the preparation or transport of radioactive materials, including loading and unloading, packaging, documentation, or general transport safety, to have proper training. In accordance with 49 CFR 172, Subpart H, operators of vehicles transporting Highway Route-Controlled Quantities of Radioactive Materials receive special training that covers the properties and hazards of the radioactive materials being transported, regulations associated with hazardous material transport, and applicable emergency procedures. Operators must be recertified every 2 years.

M.2.7 OTHER REQUIREMENTS

Organizations representing different transport modes often establish mode-specific standards. For example, all North American shipments by rail that change carriers must meet Association of American Railroads interchange rules. Equipment in interchanges must meet Association of American Railroads *Field Manual of the A.A.R. Interchange Rules* (DIRS 102592-AAR 1998, all) requirements.

The Commercial Vehicle Safety Alliance has developed inspection procedures and out-of-service criteria for commercial highway vehicles transporting transuranics, and Highway Route-Controlled Quantities of

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Radioactive Materials (see Section M.3.2.2.2). All highway shipments to a repository would be inspected under these procedures and would not leave the site until the vehicle was determined to be defect-free.

M.3 Transportation Plans and Requirements Specific to the Proposed Repository

This section describes current plans for implementing Section 137 of the NWPA, which requires DOE to utilize private industry to the fullest extent possible in each aspect of the transportation of spent nuclear fuel to a repository. These plans do not apply to shipment of naval spent nuclear fuel. The U.S. Department of the Navy would be responsible for transporting its spent nuclear fuel to the repository. Shipments of naval spent nuclear fuel would comply with the applicable regulations of the U.S. Department of Transportation, states, local governments, and Native American tribes. Shipping casks used for naval spent nuclear fuel would be certified by the U.S. Nuclear Regulatory Commission.

M.3.1 ACQUISITION OF CONTRACTOR SERVICES FOR WASTE ACCEPTANCE AND TRANSPORTATION

As required by Section 137 of the NWPA, DOE would utilize private industry to the fullest extent possible in each aspect of the transportation of spent nuclear fuel to the proposed repository. In September 1998, DOE published a draft Request for Proposal, *Acquisition of Waste Acceptance and Transportation Services for the Office of Civilian Radioactive Waste Management* (DIRS 153487-DOE 1998, all). According to this draft document, DOE would purchase services and equipment from *Regional Servicing Contractors* who would perform waste acceptance and transportation operations. If the site was approved, DOE has identified key areas of the draft Request that would require further refinement before a final solicitation, including the method of contract financing and payment. There are also specific areas related to the physical transfer of spent nuclear fuel that would be addressed before a final request. DOE is reviewing these areas and, accordingly, revising its strategy to acquire and deploy the transportation infrastructure to begin receiving shipments at Yucca Mountain in 2010. DOE would review and update the request and reissue it for further comment before issuing a final request.

As stated in the draft Request, DOE could use competitive fixed-price type or fixed-rate contracting. In addition, during several decades of operations, DOE would issue several Requests for Proposal with multiple awards, dividing the country into four regions, perhaps based on the four Nuclear Regulatory Commission regions, with one contractor to service each region. A *Regional Servicing Contractor* would receive no more than two regional servicing contracts. Regional Servicing Contractors would:

- Comply with applicable Federal (Nuclear Regulatory Commission, and U.S. Department of Transportation), state, local, and Native American regulations
- Work with utilities (generators) to determine the best way to service a site and integrate site planning into a regional servicing plan
- Provide all hardware, including transportation casks, canisters, and ancillary lifting equipment
- In conjunction with DOE, interact with state, local, and Native American governments as appropriate
- Provide all acceptance and transportation services necessary to move spent nuclear fuel from the generator sites to the proposed repository

DOE would retain responsibility for policy decisions, state and Native American relations, final route selection, and implementation of Section 180(c) of the NWPA. These activities would not be delegated to the Regional Servicing Contractor.

Under current draft plans, contracts would have three phases:

- Phase A: Development of site-specific and regional servicing plans and fixed-price bids, followed by authorization of one Regional Servicing Contractor per region to continue work into Phase B

- Phase B: Mobilization of transportation services, finalization of transportation routes and training, acquisition of transportation equipment (through lease or purchase)

- Phase C: Actual performance of acceptance activities and movement of spent nuclear fuel and high-level radioactive waste once a repository became operational

The plan for the acceptance of spent nuclear fuel would be consistent with DOE obligations under the Standard Contract (10 CFR Part 961). Acceptance schedules would be based on receiving spent nuclear fuel from generators consistent with allocations based on the acceptance priority ranking specified in the Standard Contract. In developing site-specific servicing plans, contractors could propose alternative schedules to enhance cask utilization and improve operational efficiency. The alternative schedules would require the consent and approval of the utility involved.

M.3.2 OPERATIONAL PRACTICES

Each Regional Servicing Contractor would be required to prepare a transportation plan that described the Contractor's operational strategy and delineated the steps it would implement to ensure compliance with all regulatory and other DOE requirements. This would include identification of proposed routes and associated routing considerations, coordination and communication with all participating organizations and agencies, and interactions with appropriate Federal, Native American, and state organizations. DOE would provide the draft transportation plan from each Regional Servicing Contractor selected for Phase B work to the states and tribes through whose jurisdictions spent nuclear fuel would be shipped for review and comment.

The draft Request for Proposal sets forth DOE requirements for the overall approach for transportation operations (DIRS 153487-DOE 1998, Section C, Appendix 8). These requirements are either based on or in addition to other Federal, state, or Native American regulatory requirements. Many of these practices are followed for shipments of transuranic waste to the Waste Isolation Pilot Plant in New Mexico. This section summarizes the requirements. In addition, DOE is developing transportation practices it can apply to all Department activities. The requirements or practices discussed in this section could be modified as appropriate to reflect these developing practices. In addition, DOE would implement requirements contained in applicable revisions to Federal, state, Native American, and local laws and regulations that applied to shipment of spent nuclear fuel and high-level radioactive waste.

These practices pertain primarily to activities associated with the Regional Servicing Contractor and DOE. In addition, the utility or Federal facility from which spent nuclear fuel or high-level radioactive waste would be shipped would play an important role in the transportation process. It would provide trained operators to load shipping casks and prepare them for shipment. This would include initial cask (or canister) receipt at the facility, completion of receipt inspections, and preparation activities before loading. The cask would be loaded according to the specifications listed on the Certificate of Compliance issued by the Nuclear Regulatory Commission for the particular cask. After the cask was loaded and placed on the transporter, preshipment inspections and tests would be conducted. These would include such things as leak tests, checking to ensure all lid bolts were fastened properly, and checking to see that impact limiters were attached properly. The cask would be checked for surface contamination and to ensure that radiation levels were within regulatory limits. The shipper, DOE, would be provided with the information necessary to complete the shipping papers. In the case of a highway shipment, the vehicle, load, and driver would be inspected according to procedures described in the Commercial Vehicle Safety Alliance North American Uniform Standard Out-of-Service Criteria (DIRS 156422-CVSA 2001, all) (see 49 CFR Part 397).

M.3.2.1 Planning and Mobilization

The requirements described in this section are associated primarily with Phase A and Phase B planning and mobilization activities. These requirements would be used to establish the baseline operational organization and practices to be used during early mode and route identification, fleet planning and acquisition, carrier interactions, and operations.

M.3.2.1.1 *Transportation Mode Selection*

The Regional Servicing Contractor would receive a current Delivery Commitment Schedule (described in 10 CFR Part 961) and other supporting data for each site to be serviced. These documents would provide information to support site-specific recommendations for the transportation mode, based on generator facility capabilities. This information could include a specific mode reflecting a generator's preference. In this case, the Regional Servicing Contractor would have to provide transportation systems compatible with this mode designation unless other infrastructure constraints made the generator's designation impractical. Suitability of the near-site infrastructure would be based on an evaluation of existing roads, railroads, bridges, etc., without modifications or upgrades. As stated in the draft Request for Proposal, DOE prefers to use rail transport wherever practical (DIRS 153487-DOE 1998, p. C-14). In addition, the Contractor would be required to use dedicated trains for shipments whenever such trains were determined to provide improvements in safety and enhance the efficiency of transport operations and logistics.

M.3.2.1.2 *Route Selection*

All routes used to transport radioactive waste would comply with applicable regulations of the U.S. Department of Transportation and the Nuclear Regulatory Commission. Under current planning, the Regional Servicing Contractor would have to meet the additional requirements described below when identifying proposed transportation routes (DIRS 153487-DOE 1998, all). The Contractor would consult with the other Regional Servicing Contractors as appropriate to ensure continuity and consistency of routes. All recommendations for pickup routes would be consistent with the suitability of the supporting infrastructure based on evaluations using existing roads, docks, bridges, channels, etc., without modification or upgrade, for highway routes, and would comply with the requirements in 49 CFR 397.101. After identifying a specific route, the Contractor would submit the route plan to DOE for approval. DOE would interact with states and Native American governments concerning these selections. With DOE approval, the Contractor would then submit the route plans to the Nuclear Regulatory Commission in accordance with 10 CFR 73.37(a)(7). (Actual route selection and submission to the Commission would occur 1 or more years before a route's use for shipment. Though the EIS applied the selection methodology described in this appendix, actual routes could differ from those used in the analyses.)

Almost all DOE commercial spent nuclear fuel highway shipments under a Regional Servicing Contract would be Highway Route-Controlled Quantities of Radioactive Material. Therefore, U.S. Department of Transportation routing rules (49 CFR 397 Subpart D) would apply. As specified in 49 CFR 397.101(b)(1), the Regional Servicing Contractor would have to use preferred routes that reduced time in transit.

The Regional Servicing Contractor would identify rail transportation routes in conjunction with the appropriate rail carriers. Because railroad companies determine the routing of shipments, the Contractor would rely on the rail carrier to provide primary and secondary route recommendations consistent with safe railroad operating practices. Guidelines would include consideration of track classification to ensure use of the highest rated track to the greatest extent possible, and maximum use of *key routes* as described in *Recommended Railroad Operating Practices for Transportation of Hazardous Materials* (DIRS 155658-AAR 2000, all), which requires specific inspection, maintenance, and operating procedures for key routes.

The Regional Servicing Contractor would identify barge and heavy-haul truck transportation routes in conjunction with the respective carriers and, as appropriate, discussions with state, local, U.S. Coast Guard, and U.S. Army Corps of Engineers representatives and Port Captains. Discussions about barge shipments would include development of a marine transportation plan, specific barge/cask interface requirements, availability of tug services, and identification of preshipment inspections and marine surveys. The heavy-haul truck route identification process would be in conjunction with, and in compliance with, the requirements of the routing agency of the state(s) in which shipments would occur and the applicable U.S. Department of Transportation requirements.

The Regional Servicing Contractor would be responsible for conducting studies or analyses necessary to support route recommendations, including identification of intermodal transfer locations, if needed. The Contractor would also be responsible for obtaining the necessary permits or authorizations, including payment of fees, rents, or leases associated with barge or heavy-haul truck operations.

M.3.2.1.3 *Safe Parking Areas*

Highway shipments of spent nuclear fuel or high-level radioactive waste could be delayed en route due to mechanical problems, weather or road conditions, or other unanticipated problems. In anticipation of such events, the Regional Servicing Contractor would identify safe parking areas along each highway route as part of the route determination process. The key factors in selecting a safe parking area would be (1) the desirability of a particular type of parking area and (2) the ability of the driver and crew to reach that parking area under different types of unanticipated delays or emergencies. The prioritized criteria for the identification and selection of safe parking areas include the following:

1. DOE facilities (as identified by DOE)

2. Specific places designated by DOE or the state; for example:

   - U.S. Department of Defense facilities
   - Truck stops
   - Rail sidings (with railroad concurrence)
   - Ports of entry
   - State highway service facilities
   - National Guard facilities

3. If none of the parking options under the first two choices could be reached safely, criteria for the avoidance of particular types of areas would be applied to select a suitable safe parking area. Although it might not be possible to locate a parking site that met all of the following criteria, the plan would be to avoid the following types of potential parking locations:

   - Highly populated areas
   - Hospitals and schools
   - Residential areas

- Areas with numerous pedestrians
- Heavily industrialized areas
- Areas with difficult access
- Crowded parking areas (such as shopping malls)
- Highway shoulders

Safe parking areas should also:

- Provide adequate separation from other vehicles carrying hazardous materials
- Facilitate required security (such as maintaining observation of the vehicle)
- Provide adequate driver and crew services

M.3.2.1.4 *Adverse Weather, Road, and Rail Conditions*

The Regional Servicing Contractor would obtain route weather forecast information as part of the preshipment planning and notification and shipment dispatching process. At the time of departure, current weather conditions, the weather forecast, and current travel conditions would have to be acceptable for safe vehicle operation. If these conditions were not acceptable, the shipment would be delayed until travel conditions became acceptable. The driver and crew would concur with the decision to dispatch the shipment(s). Shipments would not travel when severe weather conditions developed along routes or adverse road conditions made travel hazardous. Driver and crew communications with the control center would provide advance warning of potential adverse conditions along the route. If the shipment encountered unanticipated severe weather or adverse road conditions, the driver and crew would contact the control center to coordinate routing to a safe parking or stopping area if it became necessary to delay the shipment until conditions improved.

DOE would provide the Regional Servicing Contractor with notification of road or highway construction that could temporarily affect the planned route. DOE would obtain road and highway conditions and information on anticipated construction through consultation with the states along the planned route. Long-range highway construction planning information provided by state highway departments would be given to the Contractor. This information would aid in confirming final shipping schedules and determining if short-term alternative route planning and additional approvals by the states or the Nuclear Regulatory Commission would be required before initiating the shipments.

Rail carriers use train control and monitoring systems to identify the location of their trains within the rail system and to make informed decisions based on this information to avoid or minimize potential weather-related or track-condition risks. Under 49 CFR 174.20, the carrier can impose local restrictions on transportation when local conditions make travel hazardous. Adverse operating conditions can be reported to the DOE shipper through several means (for example, communications with the carrier or information provided by state, Native American, or local authorities).

M.3.2.1.5 *Tracking and Communication*

Shipment tracking and preshipment and communications en route would be key responsibilities of the Regional Servicing Contractor. A system that provided the necessary tracking and communications with DOE, affected governments, other Regional Servicing Contractors, and the repository would be in place at all times.

The Regional Servicing Contractor would provide continuous real-time position tracking for all shipments using the TRANSCOM satellite tracking system or an equivalent system approved by DOE. The system would provide DOE and the Contractor with a continuous, centralized monitoring and communications capability. The Contractor would be responsible for acquisition, installation, maintenance, and security of the tracking system equipment.

The Regional Servicing Contractor would develop detailed procedures to be followed in the event that the tracking system was temporarily not available. The procedures would be based on a telephone call-in system that provided for the driver or other crew member reporting the shipment location to DOE on a regular basis and before crossing state and tribal borders.

In addition to the satellite tracking system, the Regional Servicing Contractor would furnish and equip all tractors and rail escort cars with communications equipment.

M.3.2.1.6 *Carrier Management Plan*

The Regional Servicing Contractor would be responsible for selecting and using transportation carriers that complied with all applicable regulatory and DOE operational transportation requirements. The Contractor would require all carrier subcontractors to provide a carrier management plan that addressed the following areas:

- Management organization, including subcontractor management
- Driver and crew screening and hiring
- Driver and crew operations and safety training and refresher training
- Maintenance and inspection of personnel qualifications
- Maintenance program, including procedures and inspections
- Pretrip and posttrip inspection requirements
- Maintenance en route or breakdown repair or equipment replacement
- Emergency or incident response training and refresher training
- Accident or incident reporting system
- Policy for imposition of specific driver and crew penalties
- Substance abuse policy, including screening tests
- Security plan
- Quality assurance plan
- Safety program
- Records management system

M.3.2.1.7 *Carrier Personnel Qualifications*

Carriers would develop and maintain a qualification and training program that meets U.S. Department of Transportation and Nuclear Regulatory Commission requirements for drivers, engineers, crew, and security personnel. For truck drivers, qualifications include being at least 21, meeting physical standards, having a commercial driver's license, and successfully completing a road driving test in the shipment vehicle. In addition, drivers must have training on the properties and hazards of the material being transported, as well as the procedures to follow in the event of an emergency. Locomotive engineers must meet the Locomotive Engineer Certification requirements of 49 CFR Part 240, which include completing an approved training program. In addition to these requirements, driver and crew training would cover the following:

- Operation of the specific package tie-down systems

- Cask recovery procedures

- Use of radiation detection instruments

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- Use of a satellite-based tracking system and other communications equipment
- Adverse weather and safe parking procedures
- First responder awareness training
- Radiation worker B (or equivalent) training
- Enhanced inspection standards as specified in the Commercial Vehicle Safety Alliance North American Uniform Standard Out-of-Service Criteria (DIRS 156422-CVSA 2001, Paragraph 5.0)
- The "Physical Protection of Irradiated Fuel in Transit, Training Program" (10 CFR 73, Appendix D), which includes security requirements

M.3.2.2 Shipment Operations

M.3.2.2.1 *Notice of Shipments*

Advance notice of DOE shipments, ongoing status of shipments, and other pertinent shipment information would be necessary to meet regulatory requirements [10 CFR Part 71.97, 10 CFR 73.37 (f), and 10 CFR 73.72]. This information would be used to support coordination of repository receipt operations, support emergency response capabilities, identify weather or road conditions that could affect shipments, identify safe parking locations, schedule needed inspections, and coordinate public information programs.

The Regional Servicing Contractor would provide projected shipping schedules to DOE. DOE would provide schedule information to the states and tribes based on specific approved routes approximately 6 months before the initiation of planned shipments.

M.3.2.2.2 *Inspections*

Inspections of highway shipments would be conducted at the points of origin and destination using the enhanced inspection standards of the Commercial Vehicle Safety Alliance (DIRS 156422-CVSA 2001, all). DOE selected the Commercial Vehicle Safety Alliance, an international organization of state and province officials responsible for the administration and enforcement of motor carrier safety laws, to develop an inspection and enforcement program specific to spent nuclear fuel, high-level radioactive waste, transuranics and other Highway Route-Controlled Quantities of Radioactive Material. The procedures developed under this program provide uniform standards for radiation surveys, inspection of drivers, shipping papers, vehicles, and casks. The procedures set higher standards for these shipments than are contained in the North American Inspection Standards, which are used to inspect all other types of shipments. The procedures are used to inspect a shipment at point of origin. A vehicle receives a special inspection decal, good only for that shipment, if it is defect-free according to the enhanced standards. The Commercial Vehicle Safety Alliance has trained state inspection personnel on the enhanced procedures, which are currently being applied to DOE shipments (DIRS 156703-FRA 1998, all) of transuranics and other Highway Route-Controlled Quantities of Radioactive Material.

Rail shipments would be inspected in accordance with 49 CFR 174.92 and the Federal Railroad Administration's High-Level Nuclear Waste Rail Transportation Inspection Policy. The policy states (DIRS 156703-FRA 1998, Appendix A):

> *Past rail shipping campaigns of high-level nuclear waste have shown that the nature of the potential hazards associated with radioactive materials elicits a relatively high degree of public awareness and*

concern in regard to transportation of the material. As a result, the Federal Railroad Administration developed and instituted an inspection policy for rail movements of this type of hazardous material. This policy sets inspection frequency criteria above and beyond that which may normally be necessary and is implemented for all known high-level nuclear waste shipments by rail.

In addition to pre- and postshipment inspections of the transport package and crew safety inspections en route of the transport vehicles, DOE anticipates that various states and tribes could require additional vehicle inspections when shipments entered their respective jurisdictions. For barge shipments, inspections and surveys would be in accordance with U.S. Coast Guard regulations (46 CFR Parts 90 to 105). Inspections en route would be scheduled using the satellite system and other position-reporting capabilities to notify appropriate jurisdictions of the approach of a shipment so state or tribal inspection officials could be available at designated points to perform the inspection with minimal disruption to operating schedules. Inspections for rail shipments would be coordinated with normal crew change locations wherever possible to minimize additional stops.

M.3.2.2.3 *Procedures for Delays En Route*

The Regional Servicing Contractor would be responsible for providing or having carriers provide drivers and crews with specific written procedures that clearly defined detailed actions the driver and crew would take in the event of various delays en route. These include unanticipated route conditions due to civil strife or other disruptions, traffic delays due to traffic accidents not directly involving the cask shipments, emergency road or rail construction, or delays caused by sudden or unanticipated weather conditions. Procedures would address notifications, maintaining security, selecting alternative routes or route detours, or moving to the nearest safe parking area.

M.3.2.2.4 *Procedures for Off-Normal Operations (Unrelated to Accidents, Incidents, or Emergencies)*

The Regional Servicing Contractor would be responsible for providing or having carriers provide drivers and crews with specific written procedures that clearly defined detailed actions that the driver and crew would take during off-normal events. These include, but are not limited to, mechanical breakdown, fuel problems, tracking system failure, and illness, injury, or other incapacity of the driver or a member of the crew. Procedures would address notifications, deploying appropriate hazard warnings, maintaining security, obtaining medical assistance, arranging for crew replacement or for maintenance, repair, or replacement of equipment, or recovery, as appropriate.

M.3.2.2.5 *Emergency or Incident Response*

The Regional Servicing Contractor would be responsible for providing or having carriers provide drivers and crews with specific written procedures that clearly defined detailed actions they would take in the event of an emergency or incident involving property damage, injury, or the release or potential release of radioactive materials. Procedures would comply with U.S. Department of Transportation guidelines for emergency response contained in the *2000 Emergency Response Guidebook* (DIRS 155776-DOT 2000, all) and would address the following:

- Emergency assistance to injured crew or others involved
- Identification and assessment of the situation
- Notification and communication requirements
- Securing the site and controlling access
- Technical help to first responders

M.3.2.3 Postshipment Activities

Postshipment activities would include inspections of each loaded transport casks and, after completion of unloading operations, maintenance or reconfiguration and preparation of the cask and other supporting transportation system equipment for temporary parking at the proposed repository or redeployment for more shipments.

M.3.2.3.1 *Postshipment Radiological Surveys*

Receiving facility operators would survey each cask and transporter on arrival and receipt at the proposed repository and, before initiating unloading operations, would determine if any contamination beyond the limits specified in 49 CFR 173.443 occurred during transit. In addition, the cask, its tie-downs, and associated transportation system hardware would be inspected visually to ensure that no physical damage occurred during transit.

DOE, as the shipper, would be responsible for reporting any contamination or damage to the Nuclear Regulatory Commission in accordance with 10 CFR 71.95. The Department would also be responsible for notifying the utility at whose facility the shipment originated and, with the utility, for initiating corrective actions. In addition to reports required for the Nuclear Regulatory Commission, the DOE Office responsible for repository operations would provide a report to DOE Headquarters describing the incident, including probable cause, and the corrective actions taken to prevent recurrence.

M.3.2.3.2 *Shipment of Empty Transportation Casks*

Except before their first use, shipments of all empty transportation casks would comply with the requirements of the Nuclear Regulatory Commission certificate of compliance or 49 CFR 173.427, whichever was applicable. Escort and security requirements, advance shipment notifications, continuous position tracking, and inspections en route would not apply to the shipment of empty transportation casks.

M.4 Cask Safety and Testing

M.4.1 TEST REQUIREMENTS FOR CASKS

The purpose of the Nuclear Regulatory Commission regulations applicable to the transportation of spent nuclear fuel and high-level radioactive waste materials to the proposed repository is to protect the public health and safety for normal and accident conditions of transport and to safeguard and secure shipments of these materials. Regulations in 10 CFR Part 71 require that casks for shipping spent nuclear fuel must be able to meet specified radiological performance criteria for normal transport and following a sequential series of tests that represent severe accident conditions. Meeting these requirements is an integral part of the safety assurance process associated with transportation casks. The ability of a design to withstand the test conditions can be demonstrated by comparing designs to similar casks, engineering analyses (such as computer-simulated tests), or by scale-model or full-scale testing. These tests include a 9-meter (30-foot) drop onto an unyielding flat surface, a 1-meter (40-inch) drop onto a vertical steel bar, exposure of the entire package to fire for 30 minutes, and immersion in 1 meter (3 feet) of water. In addition, an undamaged cask must be able to survive submersion in the equivalent pressure of 15 meters (50 feet) and 200 meters (650 feet) of water. Studies conducted by the Nuclear Regulatory Commission show that these test conditions simulate almost all observed or anticipated accidents (DIRS 101828-Fischer et al. 1987, all; DIRS 152476-Sprung et al. 2000, all; see Section M.4.2). For most accidents more severe than those represented by the test conditions, the Nuclear Regulatory Commission studies show that the radiological criteria for containment, shielding, and subcriticality are still satisfied. The studies also show that for the few severe accidents in which these criteria could be exceeded, only containment and shielding would be affected, and the regulatory criteria could be exceeded only slightly. The following paragraphs discuss each of these tests.

M.4.1.1 Nine-Meter Drop onto an Unyielding Surface

The first test in the accident sequence simulates impact. The test is specified as a 9-meter (30-foot) free fall onto an unyielding surface with the cask striking the target in the most damaging orientation. The free fall results in a final velocity of 48 kilometers (30 miles) per hour. Although this velocity is less than the expected speed of interstate highway traffic, the test is severe because the target surface is unyielding. This results in all the energy of the drop being absorbed by the cask. There is no such thing in nature as an unyielding surface. Striking an unyielding surface at 48 kilometers per hour, when all the impact energy is absorbed by the cask, is approximately equivalent to a 97-kilometer (60 mile)-per-hour impact with a “medium” hardness surface, such as shale or other relatively soft rock, and a 150-kilometer (90 mile)-per-hour impact with a “soft” surface, such as tillable soil.

M.4.1.2 One-Meter Drop onto a Steel Bar

The second test in the sequence simulates a cask hitting a rod or bar-like object that could be present in an accident. The test is specified as a 1-meter (40-inch) drop onto a 15-centimeter (6-inch)-diameter rod sitting on the unyielding surface. The cask must be in the orientation in which maximum damage would be likely. In addition, the bar must be long enough to cause maximum damage to the cask. The test frequently evaluates several impacts in which different parts of a cask strike the bar either by simulation or physical testing. This is to demonstrate that all parts of the cask would pass the test.

M.4.1.3 Fire Test

The third test in the sequence simulates a fire occurring after the two impacts described above. The test is specified as a 30-minute engulfing hydrocarbon fire with an average flame temperature of 800°C (1,472°F). The test requires the cask to be fully engulfed in the flame for the full 30 minutes. Following an actual severe accident a cask would probably be lying on the ground in a position such that it would not be fully engulfed.

M.4.1.4 Water Immersion Tests

The fourth and final test of the sequence is a shallow immersion test. The test cask (after being subjected to the two drops and the fire) must next be immersed in 1 meter (3 feet) of water. The purpose of this test is to ensure that water cannot leak into the cask.

An undamaged version of the cask must also be able to survive immersion in the equivalent of 15 meters (50 feet) of water [a pressure of about 1,500 grams per square centimeter (22 pounds per square inch)] to test for leakage. Furthermore, shipping casks designed to hold more than 1 million curies of radioactivity must be able to survive water pressure of about 20,000 grams per square centimeter (290 pounds per square inch) for 1 hour without collapse, buckling, or leaking. That pressure is equivalent to a depth of about 200 meters (650 feet). The purpose of this standard is to ensure that casks accidentally sunk on the outer continental shelf could be retrieved with their contents intact.

M.4.1.5 Acceptance Criteria

To be judged successful in meeting these tests [except the 200-meter (650-foot) submersion], a cask must not release more than limited amounts of radioactive material in 1 week. These release limits are set for each radionuclide based on dispersivity and toxicity. In addition, it must not emit radiation at a dose rate of greater than 1 rem per hour at a distance of 1 meter (3 feet) from the cask surface. Finally, the spent nuclear fuel or high-level radioactive waste in the cask must not be capable of undergoing a nuclear chain reaction, or criticality, as a result of the test conditions. A recent study by Sandia National Laboratories for the Nuclear Regulatory Commission determined that less than 1 in 10,000 transportation accidents involving casks that satisfy the performance requirements of the Commission regulations would be severe enough to cause a release from a spent nuclear fuel cask (DIRS 152476-Sprung et al. 2000, pp. 7-73 to 7-76).

M.4.1.6 Tests Using Models

The ability of a cask to survive these tests can be demonstrated in several ways. First, an actual, full-size model of the cask can be subjected to all the tests in the sequence. As an alternative, the tests can be applied to small models of the casks (typically half- or quarter-scale). Finally, cask designs can be compared to previous licensed designs or analyzed with computer models. The Nuclear Regulatory Commission decides what level of physical testing or analysis is necessary for each cask design. Because the Commission generally accepts the results of scale-model testing, expensive full-scale testing of entire spent fuel casks is rarely conducted, although such tests are sometimes required for specific cask components. For example, the Commission could require quarter-scale drop tests for a particular cask design but full-scale tests of the cask's impact limiters (cushioning material typically attached to each end). Computer analysis could be sufficient for meeting the fire test and for criticality control.

M.4.2 STUDIES OF TRANSPORTATION ACCIDENT RISK

This section presents information from the recent report to the Nuclear Regulatory Commission from the Commission staff, "Transportation Risk Studies" (DIRS 155562-NRC 2000, all).

Federally funded studies of nuclear waste transportation accident risks have concluded that current regulations provide an adequate margin of safety. For example, the Nuclear Regulatory Commission first evaluated impacts on public health and safety from transportation activities in the *Final Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes* (DIRS 101892-NRC 1977, all). This document examined impacts from transportation by land, air, and sea transport modes under incident-free and accident conditions.

Considering the information developed and received, and the safety record associated with the transportation of radioactive material, the Commission determined that the regulations then in place were adequate to protect the public against unreasonable risk from the transport of radioactive materials, and that no immediate changes in the regulations were needed to improve safety (46 *FR* 21619; April 13, 1981). The U.S. Department of Transportation also relied on DIRS 101892-NRC (1977, all) to assess the impact of radioactive material transportation under its Hazardous Materials regulations (49 CFR Subchapter C, Parts 171 to 180).

In the mid-1980s, several shipment campaigns were initiated to return spent nuclear fuel from the West Valley Demonstration Project in western New York to the originating utilities. These campaigns drew considerable public interest, and questions focused on the difficulty in comparing the Nuclear Regulatory Commission's spent fuel cask accident standards with actual accident conditions. These standards are expressed as a series of hypothetical tests and acceptance criteria described in 10 CFR 71.73. The Commission addressed the level of safety provided by its regulations under accident conditions in a study, which is frequently referred to as the *Modal Study* conducted for the Commission by Lawrence Livermore National Laboratory [*Shipping Container Response to Severe Highway and Railway Accident Conditions* (DIRS 101828-Fischer et al. 1987, all)].

To elaborate on the DIRS 101892-NRC (1977, all) spent nuclear fuel shipment accident risk estimate, the Modal Study included an assessment of the probabilities and forces associated with severe transportation

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accidents. In addition, the Modal Study examined transport cask responses to accidents by using finite element modeling of generic cask responses to accident forces. The results indicated that spent nuclear fuel shipment risks were about one-third those estimated in DIRS 101892-NRC (1977, p. 5-51 to 5-53). From the Modal Study, the Nuclear Regulatory Commission concluded that the study clearly bounded spent nuclear fuel shipment risks, which supported the Commission's previous decision that there was no need to change transportation regulations to improve safety.

Another recent study by Sandia National Laboratories for the Nuclear Regulatory Commission, the *Reexamination of Spent Fuel Shipment Risk Estimates* (DIRS 152476-Sprung et al. 2000, all) examined whether the original Modal Study risk estimates bounded those for the anticipated shipment campaigns. Like the Modal Study, this study calculated the risks for spent nuclear fuel shipments under incident-free and accident conditions but, unlike that study, considered such factors as the design, enrichment, burn-up, and cooling time of fuel currently anticipated to be shipped; the capacity and designs of newer casks; and current population densities along road and rail routes. The results of this study continue to show that accident risk estimates are much less than those estimated in DIRS 101892-NRC (1977, all).

An ongoing transportation accident risk study, the *Package Performance Study* focuses on spent nuclear fuel cask responses to severe transportation accidents (see 65 *FR* 45629; July 24, 2000). The objective of this study is to address remaining spent nuclear fuel transportation issues from the Modal Study (DIRS 101828-Fischer et al. 1987, all) and the *Reexamination of Spent Fuel Shipment Risk Estimates* (DIRS 152476-Sprung et al. 2000, all), using a public participation approach to solicit public and stakeholder interests in developing the study's scope and parameters for review. Further, whereas the earlier studies were analytical in nature, the Package Performance Study will consider the use of physical testing to address issues, where appropriate. Risk insights obtained using current analysis techniques, physical testing, and through interaction with stakeholders and the public, will support the Nuclear Regulatory Commission's ongoing efforts to ensure that its regulatory actions are sensitive to risk and effective.

M.4.3 RESULTS FROM PREVIOUS CRASH TESTS

U.S. laboratories, with British assistance, have staged severe truck and rail accidents to study the response of full-scale spent nuclear fuel casks. Those tests, which were designed primarily to verify computer models, yielded films and photographs that have been widely cited as strong evidence of nuclear waste transportation safety, because they illustrate the robustness of these casks in accidents. Sandia National Laboratories conducted four crash tests of U.S. spent nuclear fuel casks during 1977 and 1978 (DIRS 155792-Yoshimura 1978, all). In the first test, a truck carrying a 20-metric-ton (22-ton) cask was crashed into a hard, massive, earth-backed concrete wall at 97 kilometers (60 miles) per hour, causing very little damage to the cask. The same cask was loaded onto another truck and driven into the wall at 135 kilometers (84 miles) per hour, again causing minor cask damage. In the third test, a locomotive traveling 130 kilometers (81 miles) per hour struck a 23-metric-ton (25-ton) cask on a truck trailer that was parked across the tracks. The fourth test involved crashing a railcar carrying a 67-metric-ton (74-ton) spent nuclear fuel cask into the hard, massive, earth-backed concrete wall, and the same cask and railcar were then engulfed in a jet fuel fire. After about 90 to 100 minutes, or three times the duration of the regulatory test, the fire was stopped when evidence of damage to the shield casing was observed. Although the observed damage could have reduced shielding effectiveness, it would not have impaired containment capability. The tests were intended to verify computer simulation programs used for structural analysis. They were not intended to rigorously assess containment capability, nor were the casks instrumented to do so. The experts who conducted the tests, however, made some qualitative judgments about cask performance. According to Sandia, none of the tests would have released hazardous levels of radioactivity if the casks had contained spent nuclear fuel (DIRS 155792-Yoshimura 1978, all).

A British train crash demonstration, conducted in 1984, involved a locomotive weighing 140 metric tons (154 tons) pulling three 33-metric-ton (36-ton) passenger cars at 160 kilometers (100 miles) per hour. The train struck a British Magnox spent nuclear fuel cask weighing 48 metric tons (53 tons) that had been placed on the tracks in what was believed to be its most vulnerable position. The cask held 3 metric tons (3.3 tons) of steel bars meant to simulate spent nuclear fuel. According to a report on the demonstration, the cask was positioned "so that a valve would be in the impact zone and so that the wheels and tow-hook on the locomotive would inflict maximum damage to the lid bolts" (DIRS 155791-Blythe et al. 1986, all). Extensive monitoring of the demonstration indicated that almost no cask pressure was lost and that no radioactivity would have been released by the crash. Measurements showed that the train impact was substantially less severe than the impact of the 9-meter (30-foot) drop test onto an unyielding surface. A report on the British train crash demonstration concluded that computer models could predict crash forces on spent nuclear fuel casks "with a high degree of confidence" (DIRS 155791-Blythe et al. 1986, all).

M.5 Emergency Response

M.5.1 ROLES AND RESPONSIBILITIES

As with any emergency situation in their jurisdictions, state and Native Americans governments have the primary responsibility to respond to accidents involving radioactive materials and to protect the public health and safety. State, tribal, and local emergency response personnel are the first to respond to hazardous material accidents. On arriving at the scene, first responders determine the presence or identification of hazardous materials, cordon off contaminated areas, initiate protective actions, and call for assistance from other personnel as necessary. Local responders usually contact state or tribal public health agencies. Many of those agencies have personnel trained to conduct radiological tests at the site to determine if there has been a release of radioactive material.

State, Native American, and local governments can request assistance from Federal agencies. An extensive Federal program exists to assist states and tribes in the event of an accident involving spent nuclear fuel or high-level radioactive waste. Seventeen Federal agencies participate in the program and are available to assist, if requested. A Lead Federal Agency, as defined by the "Federal Radiological Emergency Response Plan" (61 *FR* 20944; May 8, 1996), is responsible for leading and coordinating Federal on-scene actions and assisting state, tribal, and local governments in determining measures to protect life, property, and the environment. If requested, the Lead Federal Agency would ensure that other Federal agencies assisted in implementing protective actions. The Lead Federal Agency can change for different stages of an emergency.

DOE is responsible for developing policy and guidance for emergency planning, management, training, and response to an accident involving its shipments. The Department has several programs available to provide assistance to state, Native American, and local governments in response to radioactive material accidents. The Radiological Assistance Program, for example, provides trained personnel with equipment to evaluate, assess, advise, and assist in the mitigation and monitoring of potential immediate hazards associated with a transportation accident. As part of the program, DOE maintains eight Regional Coordinating Offices across the country that are staffed 24 hours a day, 365 days a year. The staff consists of nuclear engineers, health physicists, industrial hygienists, public affairs specialists, and other personnel who provide field monitoring, sampling, decontamination, communications, and other services, as requested.

DOE's Radiation Emergency Assistance Center/Training Site (REAC/TS) focuses on providing rapid medical attention to people involved in radiation accidents. REAC/TS maintains a 24-hour response center to provide direct support, including deployable equipment and personnel trained and experienced in the treatment of radiation exposure, to assist Federal, state, tribal, and local organizations.

M.5.2 ACTIONS TAKEN IN AN EMERGENCY SITUATION

During an emergency in which the carrier or escorts could communicate through the satellite tracking system or by phone if the system was not available, the carrier would contact DOE, and DOE would contact the state or tribe (who would contact the local responders), the Nuclear Regulatory Commission, and the U.S. Department of Transportation. When the first responders arrived, the carrier would assist as outlined in its emergency response plan. The first responders would investigate the potential presence of radioactive material, treat injuries, protect themselves and the public, and secure the area. As noted above, first responders would determine further appropriate emergency response actions, because they would be in charge of the accident scene. The roles and responsibilities of those who would respond to requests for assistance are described above.

If neither the carrier nor the escorts could communicate, the first responders arriving at the scene would still have information available about the shipment, such as the name of the shipper, the type of material being transported, and the telephone number to call in an emergency. This information would have been provided to the state, tribal government, or local law enforcement personnel in accordance with Nuclear Regulatory Commission regulations during the preshipment planning process and in the advance notification of shipments. In addition, the information would be available in the shipping papers accompanying the shipment, and from the labels, markings, and placards associated with the shipment. The first responders would assess the accident scene and call for state, tribal, and Federal assistance as necessary.

M.6 Technical Assistance and Funding of Emergency Response Training for Local and Native American Governments

Section 180(c) of the NWPA requires DOE to provide technical assistance and funds to states for training public safety officials of appropriate units of local and Native American governments through whose jurisdictions the Department planned to transport spent nuclear fuel or high-level radioactive waste. The training of public safety officials would cover procedures required for safe routine transportation of these materials and for dealing with emergency response situations.

DOE is responsible for implementing Section 180(c). DOE published a Notice of Revised Proposed Policy and Procedures (63 *FR* 23753; April 30, 1998) based on comments received on several previous *Federal Register* notices. In the Proposed Action proceeded, DOE would either update the Policy and Procedures as a Final Policy, or could promulgate regulations.

The following list provides selected highlights of the Notice of Revised Proposed Policy and Procedures:

- DOE would implement Section 180(c) through a grants program. DOE would administer the grants, which would be specific to the Section 180(c) program. The Department would adopt, to the extent practicable, any future DOE-wide standardization of assistance to states and tribes for the Department's radioactive materials shipments. This could include standardization of funding mechanisms, training standards, equipment purchases, and definition of technical assistance.

- DOE anticipates that it would know approximately 5 years before shipments occurred, the states or Native American, lands through which the shipments would travel, even if exact routes had not been selected. Using this information, DOE would notify those jurisdictions about their eligibility under Section 180(c).

- DOE has expanded eligibility to include those jurisdictions where a route carrying spent nuclear fuel and high-level radioactive waste shipments constitutes the border between two jurisdictions (for example, between a state and tribal lands, or between two states).

- For emergency response procedures, DOE would provide funding and technical assistance to eligible jurisdictions to address incremental training requirements resulting from spent nuclear fuel and high-level radioactive waste shipments. Specifically, the Department would provide funding and technical assistance for eligible jurisdictions to obtain and maintain awareness-level training for local response jurisdictions in the increment specific to radioactive materials shipments. In addition, to the extent funds were available, the assistance could be used to obtain an enhanced level of emergency response capability to include operations-level training, technical-level training, and the corresponding refresher training, all in an increment specific to radioactive materials shipments.

- For safe routine transportation procedures, DOE would provide funding and technical assistance to eligible jurisdictions to prepare for safety and enforcement inspections of spent nuclear fuel and high-level radioactive waste shipments and for access to satellite tracking information.

- The application process should take about a year. A one-time planning grant of $150,000 would be provided to eligible states and tribal jurisdictions for determining training and funding needs and for preparing an application in about 2006 (4 years before shipments began). DOE expects the application to include a 5-year plan detailing how the funds would be spent each year. In about 2007, the base grant for planning and coordination would be provided. In about 2008 to 2010, funds would be provided for training and the purchase of equipment. Local governments could not receive Section 180(c) grants or technical assistance directly from DOE.

- DOE would allow a variety of activities that an applicant might consider appropriate for training under Section 180(c). For example, it would be the applicant's decision who received training and which organization would administer the training. The Notice of Revised Proposed Policy and Procedures strengthens the requirement that first responders be the recipients of the awareness-level training. In addition, an applicant would be able to budget as much as 25 percent of its total Section 180(c) funds to purchase appropriate (training-related) equipment for the 2 years prior to shipment. After that, the applicant would be able to budget as much as 10 percent of the total Section 180(c) funds to purchase equipment.

M.7 Physical Protection of Spent Nuclear Fuel in Transport

Spent nuclear fuel contains small concentrations of fissile plutonium (generally less than 1 percent). If chemically separated from the spent nuclear fuel and refined, some of this plutonium could be used to produce explosive nuclear devices. To protect against this potential, regulations are established to ensure protection of shipments from illegal diversion. Because the fissile material is in low concentration and a difficult-to-retrieve form, the threat of diversion of a spent nuclear fuel shipment to obtain these materials would be slight.

In addition, shipments must be protected from sabotage. Initial studies of the effects of sabotage on spent nuclear fuel casks suggested the possibility of severe consequences. Although later studies and experiments found these initial studies to overpredict potential consequences, these initial predictions led the Nuclear Regulatory Commission to develop a set of rules specifically aimed at protecting the public from harm that could result from sabotage of spent nuclear fuel casks. Known as physical protection or safeguard regulations (10 CFR 73.37), these security rules are distinguished from other regulations that deal with issues of safety affecting the environment and public health. The objectives of the safeguard regulations are to:

- Minimize the possibility of sabotage
- Facilitate recovery of spent nuclear fuel shipments that could come under control of unauthorized persons

To achieve these objectives, the Nuclear Regulatory Commission safeguard rules require:

- Advance notification of each shipment to the Nuclear Regulatory Commission, the states, and Native American governments (see Section M.2.5)
- The licensee to have current procedures to cope with safeguard emergencies
- Instructions for escorts on how to determine if a threat exists and how to deal with it
- Maintenance of a communications center to continually monitor the progress of each shipment
- A written log describing the shipment and significant events during the shipment
- Advance arrangements with law enforcement agencies along the route
- Advance route approval by the Nuclear Regulatory Commission
- Avoidance of intermediate stops to the extent practicable
- At least one escort to maintain visual surveillance of the shipment during stops
- Shipment escorts to report status on a regular basis
- Armed escorts in heavily populated areas
- Onboard communications equipment
- Protection of specific shipment information

The expected threat of sabotage is based on several factors, including the desirability of attacking a spent nuclear fuel cask, availability of devices that a saboteur could use and the portability of such devices, skills required to use selected devices, and capability of the device to damage a robust spent nuclear fuel cask.

The safety features included in the design of a spent nuclear fuel cask that provide containment, shielding, and thermal protection also provide protection against sabotage. The casks would be massive. The spent nuclear fuel in a cask would typically be only about 10 percent of the gross weight; the remaining 90 percent would be shielding and structure.

Specific test programs have been conducted (DIRS 156313-Sandoval et al. 1983, all; DIRS 101921-Schmidt, Walters, and Trott 1982, all) to determine the nature and quantities of material that could be released from a spent nuclear fuel cask in sabotage events. These test programs confirmed that earlier studies (DIRS 155054-Finley et al. 1980, all) over-predicted potential consequences. The results of the

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tests indicate that the regulations, which were based on the earlier, more conservative estimates, are adequate to protect the public.

The Nuclear Regulatory Commission, along with other Federal agencies, continually monitors and evaluates threat assessments, which would enable revision of the regulations, if necessary.

M.8 Liability

The Price-Anderson Act [Section 170 of the Atomic Energy Act, as amended (42 U.S.C. 2011 *et seq.*)] provides indemnification for liability for nuclear incidents that apply to the proposed Yucca Mountain Repository. The following sections address specific details or provisions of the Act.

M.8.1 THE PRICE-ANDERSON ACT

In 1957, Congress enacted the Price-Anderson Act as an amendment to the Atomic Energy Act to encourage the development of the nuclear industry and to ensure prompt and equitable compensation in the event of a nuclear incident. Specifically, the Price-Anderson Act establishes a system of financial protection for persons who may be liable for and persons who may be injured by a nuclear incident. The purpose of the Act was (1) to encourage growth and development of the nuclear industry through the increased participation of private industry, and (2) to protect the public by ensuring that funds are available to compensate victims for damages and injuries sustained in the event of a nuclear incident. Congress renewed and amended the indemnification provisions in 1966, 1969, 1975, and 1988. The 1988 Price-Anderson Amendments Act extended the Act for 14 years until August 1, 2002 (Public Law 100-408, 102 Stat. 1066). DOE has recommended that Congress extend the Act in substantially the same form [see *Report to Congress on the Price-Anderson Act* (DIRS 155789-DOE 1999, all)].

M.8.2 INDEMNIFICATION PROVIDED BY THE PRICE-ANDERSON ACT

DOE must include an agreement of indemnification in each DOE contract that involves the risk of a nuclear incident. This indemnification (1) provides omnibus coverage of all persons who might be legally liable, (2) indemnifies fully all legal liability up to the statutory limit on such liability (currently $9.43 billion for a nuclear incident in the United States), (3) covers all DOE contractual activity that could result in a nuclear incident in the United States, (4) is not subject to the usual limitation on the availability of appropriated funds, and (5) is mandatory and exclusive.

M.8.3 LIABILITY COVERED AND LIABILITY EXCLUDED BY THE INDEMNITY

The Price-Anderson Act indemnifies liability arising out of or resulting from a nuclear incident or precautionary evacuation, including all reasonable additional costs incurred by a state or a political subdivision of a state, in the course of responding to a nuclear incident or a precautionary evacuation. It excludes (1) claims under state or Federal worker compensation acts of employees or persons indemnified who are employed at the site of and in connection with the activity where the nuclear incident occurs, (2) claims arising out of an act of war, and (3) claims involving certain property located on the site.

M.8.4 DEFINITION OF A NUCLEAR INCIDENT UNDER THE PRICE-ANDERSON ACT

A *nuclear incident* is any occurrence, including an extraordinary nuclear occurrence, causing bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material (42 U.S.C. 2014).

M.8.5 PROVISIONS FOR A PRECAUTIONARY EVACUATION

A *precautionary evacuation* is an evacuation of the public within a specified area near a nuclear facility or the transportation route in the case of an accident involving transportation of source material, special nuclear material, byproduct material, spent nuclear fuel, high-level radioactive waste, or transuranic waste. It must be the result of an event that is not classified as a nuclear incident but poses an imminent danger of injury or damage from radiological properties of such nuclear materials and causes an evacuation. The evacuation must be initiated by an official of a state or a political subdivision of a state who is authorized by state law to initiate such an evacuation and who reasonably determined that such an evacuation was necessary to protect the public health and safety.

M.8.6 AMOUNT OF INDEMNIFICATION

The Price-Anderson Act establishes a system of private insurance and Federal indemnification to ensure compensation for damage or injuries suffered by the public in a nuclear incident. The current amount of $9.43 billion reflects a threshold level beyond which Congress would review the need for additional payment of claims in the case of a nuclear incident with catastrophic damage. The limit for incidents occurring outside the United States is $100 million and requires the nuclear material to be owned by and under contract with the United States.

M.8.7 INDEMNIFIED TRANSPORTATION ACTIVITIES

DOE indemnifies any nuclear incident arising in the course of any transportation activities conducted in connection with a DOE contractual activity, including transportation of nuclear materials to and from DOE facilities.

M.8.8 COVERED NUCLEAR WASTE ACTIVITIES

The indemnification specifically includes nuclear waste activities that DOE undertakes involving the storage, handling, transportation, treatment, disposal of, or research and development on spent nuclear fuel, high-level radioactive waste, or transuranic waste. It covers liability for accidents that could occur while spent nuclear fuel and high-level radioactive waste was in transit from nuclear powerplants to the proposed repository, at a storage facility, or at the repository. If a DOE contractor or other person indemnified was liable for the nuclear incident or a precautionary evacuation resulting from its contractual activities, that person would be indemnified for that liability. While DOE's own tort liability would be determined under the Federal Tort Claims Act, DOE could use contractors to transport spent nuclear fuel and high-level radioactive waste and to construct and operate a repository, if such a repository was approved under the NWPA. Moreover, if public liability arose out of nuclear waste activities funded by the Nuclear Waste Fund subject to a DOE agreement of indemnification, compensation must be paid from that fund up to the maximum amount of protection. The Fund, established by the NWPA, pays for DOE activities involved with the proposed repository.

M.8.9 STATE, NATIVE AMERICAN, AND LOCAL GOVERNMENT PERSONS WHO ARE INDEMNIFIED

State, Native American, and local governments are included among the "persons" who may be indemnified if they incur legal liability. A *person* includes "(1) any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than [DOE or the Nuclear Regulatory] Commission, any state or any political subdivision of, or any political entity within a state, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing" (42 U.S.C. 2214). A state or a political subdivision of a state may be entitled to be indemnified for legal liability, including all reasonable additional costs incurred in the course of responding to a nuclear incident or an authorized precautionary evacuation. In addition, indemnified persons could include contractors, subcontractors, suppliers, shippers, transporters, emergency response workers, health professional personnel, workers, and victims.

M.8.10 PROCEDURES FOR CLAIMS AND LITIGATION

Numerous provisions ensure the prompt availability and equitable distribution of compensation, including emergency assistance payments, consolidation and prioritization of claims in one Federal court, channeling of liability to one source of funds, and waiver of certain defenses in the event of a large accident. The Price-Anderson Act authorizes payments for the purpose of providing immediate assistance following a nuclear incident. In addition, it provides for the establishment of coordinated procedures for the prompt handling, investigation, and settlement of claims resulting from a nuclear incident.

M.8.11 FEDERAL JURISDICTION OVER CLAIMS

The U.S. District Court for the district in which a nuclear incident occurs shall have original jurisdiction "with respect to any [suit asserting] public liability...without regard to the citizenship of any party or the amount in controversy" [42 U.S.C. 2210(n)]. If a case is brought in another court, it must be removed to the U.S. District Court with jurisdiction upon motion of a defendant, the Nuclear Regulatory Commission, or DOE.

M.8.12 CHANNELING LIABILITY TO ONE SOURCE OF FUNDS

The Price-Anderson Act channels the indemnification (that is, the payment of all claims arising from the legal liability of any person for a nuclear incident) to one source of funds. This "economic channeling" eliminates the need to sue all potential defendants or to allocate legal liability among multiple potential defendants. Economic channeling results from the broad definition of "persons indemnified" to include any person who may be legally liable for a nuclear incident. Thus, regardless of who is found legally liable for a nuclear incident resulting from a DOE contractual activity or Nuclear Regulatory Commission-licensed activity, the indemnity will pay the claim.

In the hearings on the original Act, "the question of protecting the public was raised where some unusual incident, such as negligence in maintaining an airplane motor, should cause an airplane to crash into a reactor and thereby cause damage to the public. Under this bill, the public is protected and the airplane company can also take advantage of the indemnification and other proceedings" (DIRS 155789-DOE 1999, p.12).

M.8.13 STATE TORT LAW ESTABLISHES LEGAL LIABILITY

Legal liability is not defined in the Price-Anderson Act, but the legislative history indicates clearly that state tort law determines what legal liabilities are covered (DIRS 155789-DOE 1999, p. A-6). In 1988, "public liability action" was defined to explicitly state that "the substantive rules for decision in such action shall be derived from the law of the state in which the nuclear incident involved occurs, unless such law is inconsistent with the provisions of [Section 2210 of Title 42]" (42 U.S.C. 2014).

M.8.14 PROVISIONS WHERE STATE TORT LAW MAY BE WAIVED

The Price-Anderson Act includes provisions to minimize protracted litigation and to eliminate the need to prove the fault of or to allocate legal liability among various potential defendants. Certain provisions of state law may be superseded by uniform rules prescribed by the Act, such as the limitation on the awarding of punitive damages. In the case of an extraordinary nuclear occurrence (that is, any nuclear incident that causes substantial offsite damage), the Act imposes strict liability by requiring the waiver of any defenses related to conduct of the claimant or fault of any person indemnified. Such waivers would result, in effect, in strict liability, the elimination of charitable and governmental immunities, and the substitution of a 3-year discovery rule in place of statutes of limitations that would normally bar all suits after a specified number of years.

M.8.15 COVERAGE AVAILABLE FOR ACCIDENTS IF THE PRICE-ANDERSON ACT DOES NOT APPLY

If an accident does not involve the actual release of radioactive materials or a precautionary evacuation is not authorized, Price-Anderson indemnification does not apply. If the Price-Anderson Act indemnification does not apply, liability is determined under state law, as it would be for any other type of transportation accident. Private insurance could apply. As noted above, however, all DOE contracts for transportation of spent nuclear fuel and high-level radioactive waste to a repository would be covered by the Price-Anderson Act for nuclear incidents and precautionary evacuation. Persons indemnified under that DOE contractual activity would include the contractors, subcontractors, suppliers, state, Native American, and local governments, shippers and transporters, emergency response workers and all other workers and victims.

Carriers may have private insurance to cover liability from a non-nuclear incident and for environmental restoration for such incidents. All motor vehicles carrying spent nuclear fuel or high-level radioactive waste are required by the Motor Carrier Act, (42 U.S.C. 10927), and implementing regulations (49 CFR Part 387), to maintain financial responsibility of at least $5 million. Federal law does not require rail, barge, or air carriers of radioactive materials to maintain liability coverage, although these carriers often voluntarily cover such insurance. Private insurance policies often exclude coverage of nuclear accidents. Thus, private insurance policies only apply to the extent that Price-Anderson is not applicable.

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