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Time/Motion Observations and Dose Analysis of Reactor Loading, Transportation, and Dry Unloading of an Overweight Truck Spent Fuel Shipment

C. J. Hostick
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April 1992

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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SUMMARY

This document presents observed activity durations and radiation dose analyses for an overweight truck shipment of pressurized water reactor (PWR) spent fuel from the Surry Power Station in Virginia to the Idaho National Engineering Laboratory. The shipment consisted of a TN-8L shipping cask carrying three 9-year-old PWR spent fuel assemblies. Handling times and dose analyses for at-reactor activities were completed by Virginia Electric and Power Company (Virginia Power) personnel. Observations of in-transit and unloading activities were made by Pacific Northwest Laboratory (PNL) personnel, who followed the shipment for approximately 2800 miles and observed cask unloading activities. In-transit dose estimates were calculated using dose rate maps provided by Virginia Power for a fully loaded TN-8L shipping cask. The dose analysis for the cask unloading operations is based on the observations of PNL personnel.

A summary of observed handling times and dose analysis is shown in Table S.1. It should be noted that over 72% of the dose received during cask loading operations at the reactor is due to background radiation. In-transit doses were calculated for the drivers using the dose rate map for the TN-8L shipping cask and represent 35.9 person-mrem or 66% of the in-transit dose.

TABLE S.1. Activity Durations and Associated Radiation Doses for Transport of Spent Reactor Fuel Using a TN-8L Overweight Truck Cask

Activity	Time (hr)	Dose (person-mrem)
Reactor Loading	14.1	136
In-transit	62.0	54
Dry Unloading	8.2	131

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FIGURES

TABLES

1.0 INTRODUCTION

To provide information for a study of repository transportation system alternatives, personnel from Pacific Northwest Laboratory (PNL) collected cask handling and transport times and calculated personnel exposure resulting from the transportation by truck of spent nuclear fuel from the Surry Power Station in Virginia [operated by Virginia Electric and Power Company (Virginia Power)] to the Department of Energy's (DOE) Test Area North (TAN) facility at the Idaho National Engineering Laboratory (INEL). Information was collected on the Surry Power Station spent fuel shipment because it is representative of part of the expected repository transportation system. The shipment consisted of wet-cask loading at the reactor, cross-country haul, and dry-cask unloading into a hot shop. The analyses of at-reactor cask loading was prepared by Virginia Power personnel. In-transit data were obtained by PNL personnel who followed the approximately 2800 mile shipment. Shipping cask unloading at INEL was also observed by PNL personnel. This document provides additional information in support of the study of federal waste management system transportation alternatives being completed by PNL for the DOE (DOE 1987).

Data collected by Virginia Power were used to calculate occupational dose estimates for spent fuel cask handling, wet loading, and shipping for at-reactor operations. The TN-8L dose rate map, also provided by Virginia Power, and the in-transit data collected by PNL personnel were used to calculate public dose estimates for the cross-country haul. The data collected by PNL personnel at INEL during cask receiving, handling, and dry unloading operations was used to calculate occupational dose estimates for dry unloading.

The spent fuel was transported by an overweight truck consisting of a Transnuclear (TN) Inc. shipping cask containing three pressurized water reactor (PWR) spent fuel assemblies with an average cooling time of 9 years. This document presents data collected during April of 1986 on shipment number 20 of the 23 shipments completed by the Surry Power Station. Shipments 8 through 23 followed the route shown in Figure 1.1. Shipments 1 through 7 followed a different route and are not addressed in this document. A

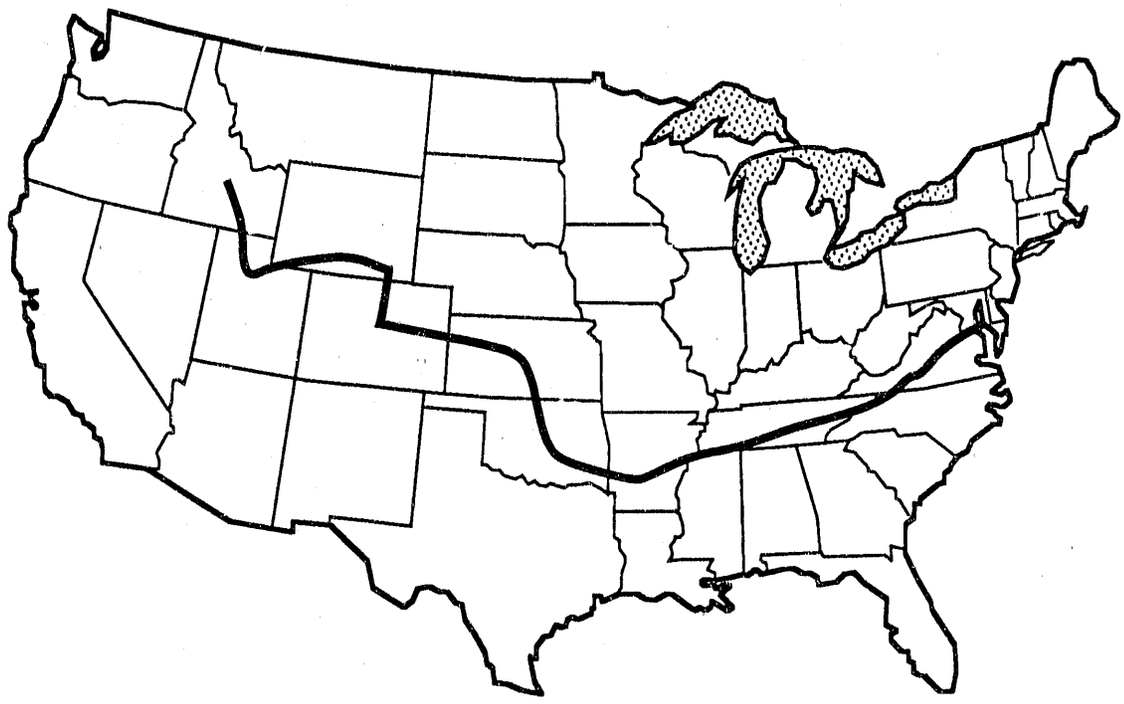


FIGURE 1.1. Route Used to Transport Spent Fuel from Virginia to INEL

description of the TN-8L shipping cask is presented in Section 1.1, and the applicable regulations for spent fuel shipments are presented in Section 1.2.

1.1 TN-8L CASK DESCRIPTION

The 40-ton TN-8L shipping casks are designed for overweight truck shipments of about 1.4 metric tons of uranium (MTU) of spent fuel. Gross vehicle weight is approximately 105,000 pounds. The TN-8L cask, designed for PWR spent fuel assemblies, is constructed of steel with lead for gamma shielding and a solid hydrogenous material for neutron shielding. A radial cross section of the cask is shown in Figure 1.2. The three spent fuel assembly compartments are surrounded by lead gamma shielding. Between the lead shielding and the outer steel shell is a layer of cement. Located externally to the outer steel shell are a solid hydrogenous material neutron shield and radial copper fins. The stainless steel lid contains lead and resin shielding, and the removable impact limiters are constructed of carbon steel and balsa wood. An isometric view of the TN-8L cask is shown in Figure 1.3.

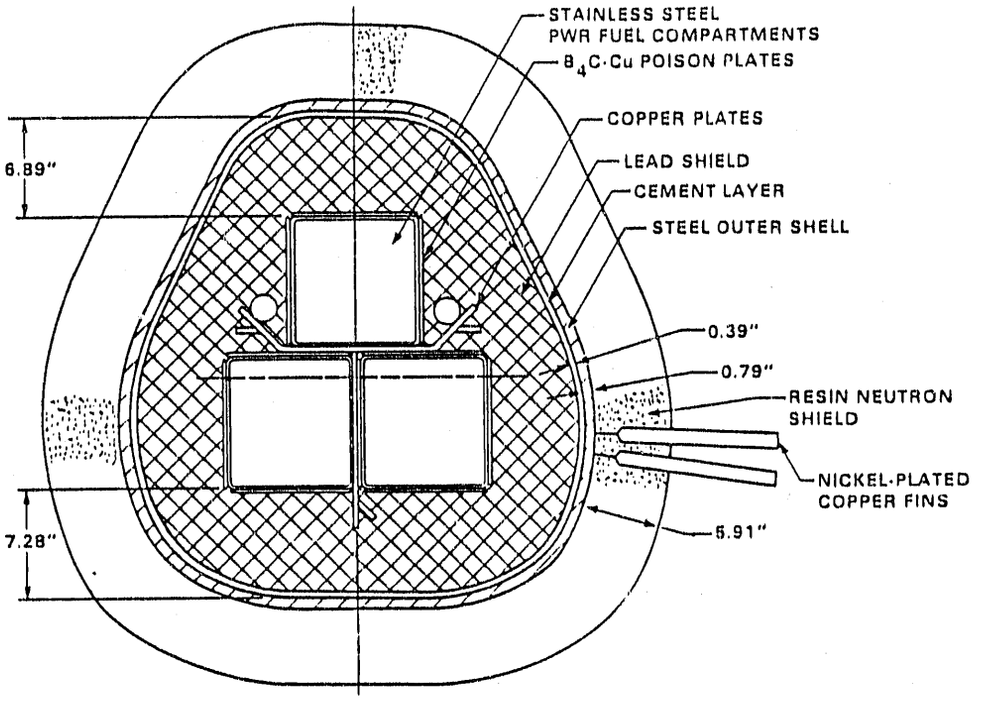


FIGURE 1.2. Radial Cross-Section of the TN-8L Cask

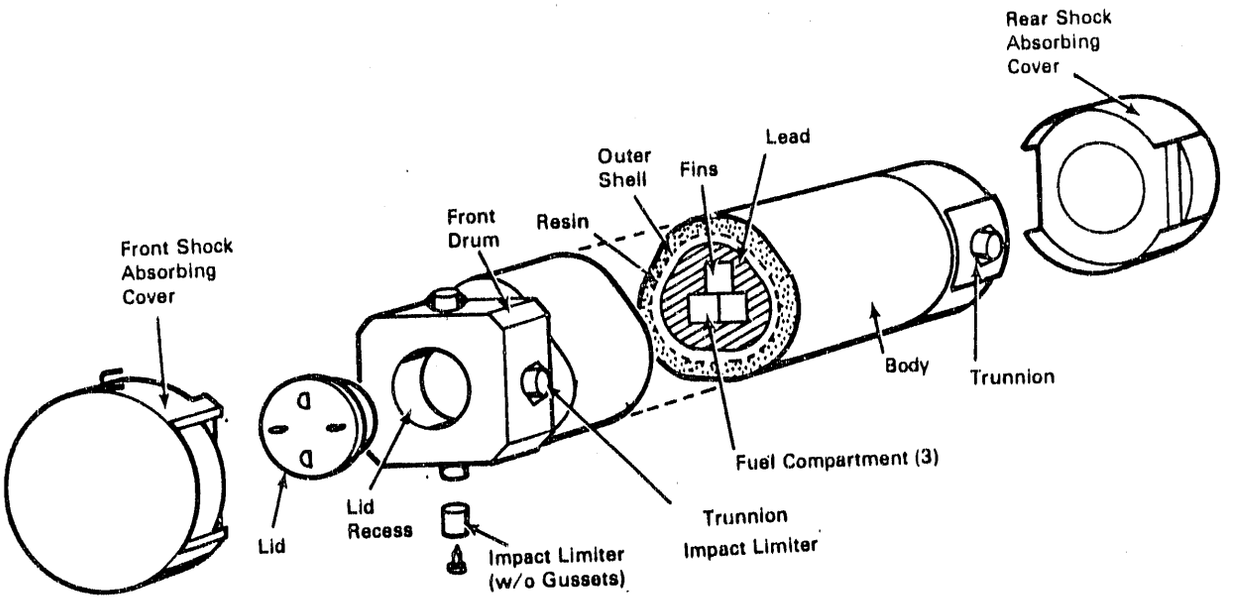


FIGURE 1.3. Isometric View of the TN-8L Cask

The lid is secured by 16 1-1/4-inch-diameter bolts and two O-rings located within recessed grooves on the top flange. The impact limiters are attached to the cask by eight 1-1/4-inch bolts. Rear cask tiedowns to the trailer consist of two clamps (one clamp on each side), which are secured by two bolts each. The front tiedowns consist of two quick release clamps extending from the trailer bed over the front trunnions, as shown by Figure 1.4. All trunnions are protected by a small impact limiter secured by one bolt while in transit. The personnel barrier consists of a tarpaulin covering a collapsible frame. The loaded trailer and closed personnel barrier is shown in Figure 1.5.

1.2 STATE AND FEDERAL REGULATIONS

This section summarizes the state and federal regulations regarding overweight or oversize shipments of spent fuel. Section 1.2.1, which summarizes the federal regulations, was taken from 49 CFR 171-177 and applies to

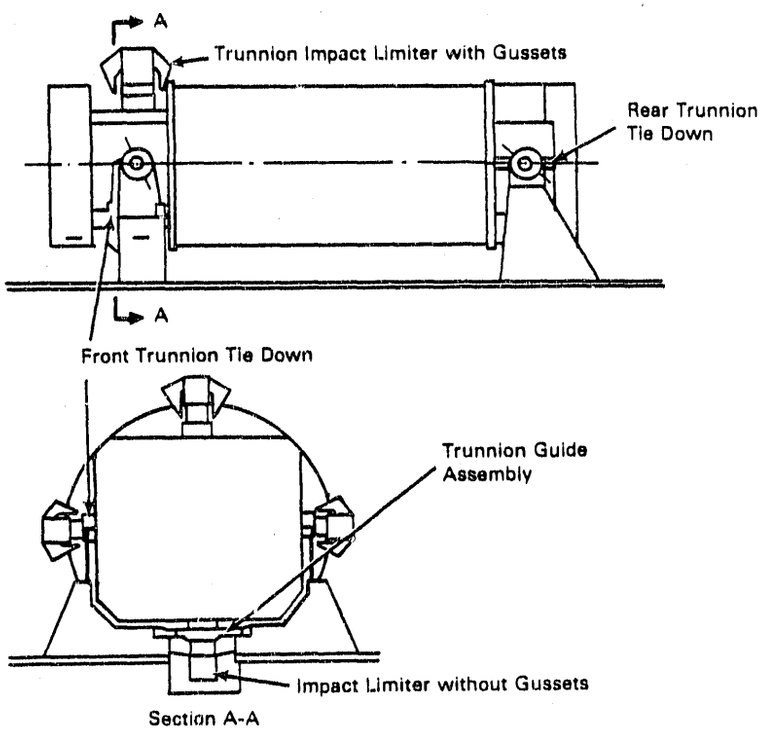


FIGURE 1.4. TN-8L Cask Transport Arrangement

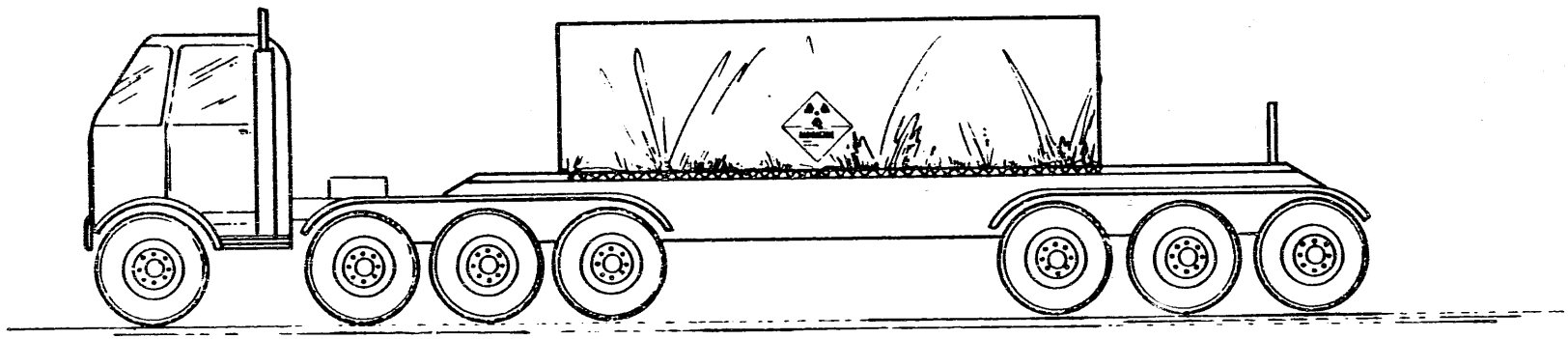


FIGURE 1.5. Loaded TN-8L Cask Shipment

all states encountered enroute to INEL. The state regulations, summarized in Section 1.2.2, usually apply in addition to the federal regulations. The state regulations described apply only to the states passed through enroute.

1.2.1 Federal Regulations

Shipments of spent fuel are regulated by one or more of four federal agencies: the U.S. Department of Transportation (DOT), the DOE, the U.S. Nuclear Regulatory Commission (NRC), and the Interstate Commerce Commission (ICC). The ICC is principally responsible for the economics of transporting nuclear materials. The other agencies are responsible for the safe transport of hazardous materials or spent nuclear fuel.

The regulations have been designed to ensure the safe transport of hazardous or radioactive materials. The regulations include provisions for route selection, the performance and design of shipping packages, vehicle safety, and the physical protection of the shipment (e.g., protection from sabotage). These regulations are intended to reduce the potential for routine public and occupational exposures and to protect the public and the environment from accidental releases.

The specific regulations that apply to shipments of spent fuel are contained in the U.S. Code of Federal Regulations (CFR). Regulations governing the shipment of spent fuel by truck are contained in the following CFR sections:

- 49 CFR 107. Rule-Making Procedures for the Materials Transportation Bureau
- 49 CFR 171. General Information, Regulations, and Definitions
- 49 CFR 172. Hazardous Materials Table and Hazardous Materials Communications Regulations
- 49 CFR 173. Shippers--General Requirements for Shipments and Packages
- 49 CFR 177. Carriage by Public Highway
- 49 CFR 178. Shipping Container Specifications
- 10 CFR 71. Package and Radioactive Material for Transport and Transportation of Radioactive Material under Certain Circumstances

- 10 CFR 73. Physical Protection of Plants and Materials.

Two of the above sections are relevant to this study and will be discussed briefly in the following paragraphs: 49 CFR 177, Carriage by Public Highway and 49 CFR 178, Shipping Container Specifications. (For further information on these sections, refer to the pertinent sections in 49 CFR.)

The DOT routing regulations (49 CFR 177.825) have been designed to reduce the impacts of transporting nuclear materials and to identify the responsibilities and roles of state and local governments in the route selection process. Routes are normally selected that will reduce shipment times and routine exposures to the public. Shippers of hazardous or radioactive materials are generally required to use interstates and preapproved routes to bypass highly populated areas.

Shipping containers or casks used during offsite shipments of commercial spent fuel must be designed to survive extreme test conditions (10 CFR 71.73) and must be licensed by the NRC. These tests include immersion, free drop, fire, and puncture. These packages are also designed to limit the amount of radiation emitted from the package. These amounts or limits are specified in 49 CFR 173.441 and are as follows:

- 1000 mR/hr at 1 m from the exterior of the package (in a closed transport vehicle only)
- 200 mR/hr at any point on the external surface of the car or vehicle (in a closed transport vehicle only)
- 10 mR/hr at any point 2 m from the vertical planes projected from the outer surfaces of the car or vehicle (in a closed transport vehicle only) or 2 m from the outer edges of the transport vehicle (as in the observed shipment)
- 2 mR/hr in any normally occupied position in the car or vehicle.

1.2.2 State Regulations

This subsection discusses the special regulations that were in effect at the time of shipment number 20 from the Surry Power Station. The regulations include overweight or oversize travel restrictions, and restrictions or regulations applying specifically to radioactive materials.

The regulations that are identified for each state are in addition to the requirements identified in 49 CFR. All states, except Idaho and Oklahoma, have passed legislation regarding the transportation of spent fuel through their respective states (Knox et al. 1986). Over a period of time, overweight shipments can damage bridges, overpasses, or road surfaces; therefore, some states have regulated overweight shipments generally through the use of increased tariffs. Travel restrictions during nights, weekends, or holidays are also used to regulate overweight and oversize shipments.

The following subsections discuss each of the state's restrictions regarding the transportation of hazardous materials and/or nonstandard (overweight or oversize) shipments. Not all of the restrictions discussed were applicable to this particular shipment (i.e., routing, etc.). Each state will be discussed in the same order as they were encountered during the shipment. Figure 1.1 shows the route followed from the Surry Power Station to INEL.

1.2.2.1 Virginia (1986 Regulations)

Virginia requires the Coordinator of the Office of Emergency Services (COES) be notified 5 days prior to shipment of spent fuel. This notification must include the proposed route and method of transportation, the time of transportation, the material to be transported, and additional materials requested by the COES (Knox et al. 1986). The 5-day period will allow the COES sufficient time to approve the proposed route, to notify all cities along the proposed route, or disapprove a route and notify the shipper.

Nonstandard shipments, such as spent fuel shipment number 20, require that traffic be stopped on two-lane bridges, allowing the shipment to cross in the center of the bridge. Virginia also restricts nonstandard shipments during holidays, the half days adjacent to holidays, and nights.

Although not required by state regulation, Virginia Power provided two escort vehicles for the shipment. The purpose of these vehicles was to maintain a constant surveillance of the shipment to the state border.

1.2.2.2 North Carolina (1986 Regulations)

North Carolina requires the shipper to notify, in advance, the State Highway Patrol prior to transporting spent fuel. The State Radiation Protection Commission has the power to amend or repeal any of the rules governing the shipment of spent fuel.

Nonstandard shipments are restricted during holidays and the adjacent Mondays, Saturdays and Sundays, and at night.

1.2.2.3 Tennessee (1986 Regulations)

Tennessee has legislation requiring that radiation monitoring equipment be available at motor vehicle inspection and weigh stations in Knox, Coffee, Hayword, and Robinson Counties. This legislation also requires or provides training programs to familiarize state officials with the use of the equipment. Tennessee enacted legislation naming the Public Service Commission (PSC) as the licenser and regulator of all motor vehicles involved in the transport of spent fuel. The PSC issues interstate permits allowing the carrier to transport spent fuel. The PSC, in agreement with the Tennessee Department of Transportation, inspects the carrier's vehicle and performs a radiation survey at the port of entry.

Overweight shipments, such as shipment number 20, are also assessed an additional tax of $0.05 for each pound in excess of the legal shipping weight. Tennessee also requires that nonstandard shipments, regardless of the material transported, be made during daylight hours only; however, 6 hours of negotiations between the carrier and the state resulted in the waiver of this restriction for the shipments from Surry Power Station to INEL, so shipment number 20 passed through Tennessee at night.

1.2.2.4 Arkansas (1986 Regulations)

Arkansas has no legislation specifically regulating the transportation of spent fuel (Knox et al. 1986). However, Arkansas has legislation regarding spills, accidents, and the identification of hazardous materials. It can be assumed that these regulations apply to shipments of spent fuel.

Arkansas also requires that nonstandard shipments be made during daylight hours only. However, negotiations with the state resulted in a waiver of this restriction for the shipments from Surry Power Station to INEL.

1.2.2.5 Oklahoma (1986 Regulations)

As of April 1986, Oklahoma had no legislation regarding the transport of spent nuclear fuel. There are no restrictions regarding overweight shipments in effect at that time.

1.2.2.6 Kansas (1986 Regulations)

The State of Kansas requests a notification in writing 10 days prior to arrival of the first shipment and the completion of the last shipment through the state. In this notification, the route, time frame, enter/exit points, and emergency contact(s) are identified.

Kansas restricts overweight shipments during holidays, on the evening of the last day of a holiday, on Sundays, and at night.

1.2.2.7 Colorado (1986 Regulations)

Colorado has identified the State Board of Health as the agency to adopt and identify regulations regarding the shipment of any radioactive materials. The Manager of Safety has been designated to regulate shipments in the County of Denver, including the City of Denver. The manager identifies and approves the routes to be used. The Director of Excise and Licenses approves the shipper's request for an application to ship hazardous materials and also collects an applicant's fee.

Nonstandard shipments are restricted during holidays, Saturday evenings, Sundays, and at night.

1.2.2.8 Wyoming (1986 Regulations)

No legislation has been identified for Wyoming (Knox et al. 1986). The governor, by Governor Order, has requested that shippers of radioactive materials contact the State Patrol prior to entry and wait at the port of entry for a State Patrol escort through the state. It is then the responsibility

of the State Patrol to provide an escort vehicle through each district of the state. This vehicle is to maintain constant surveillance of the transport vehicle.

Nonstandard shipments can be made during daylight hours only.

1.2.2.9 Utah (1986 Regulations)

Utah has passed legislation adopting the DOT regulations regarding shipments of hazardous materials and has no specified nonstandard shipment restrictions.

1.2.2.10 Idaho (1986 Regulations)

Idaho has not passed any legislation regulating the transport of spent nuclear fuel within its boundaries (Knox et al. 1986). The travel of nonstandard shipments is restricted during holidays, Saturday evenings, Sundays, and at night.

1.2.3 Impacts of State Regulations

Negotiations between the carrier and the states encountered enroute from the Surry Power Station to INEL were held prior to the shipping campaign. These negotiations resulted in waivers for most of the restrictions that are applicable to nonstandard and hazardous materials shipments. Three restrictions were not waived; however, these restriction did not severely impact the shipment. The three restrictions enforced by the states were:

- Virginia - State police stopped traffic when the shipment crossed over a small bridge.
- Tennessee - Tennessee DOT inspected the vehicle and surveyed the shipment at the port of entry.
- Wyoming - Required a state police escort from the port of entry to the Utah border.

1.3 REPORT ORGANIZATION

This report is divided into four chapters and four appendices. In Chapter 2.0, the analyses of at-reactor cask loading is presented. Chapter 3.0 contains the in-transit data, and shipping cask unloading at INEL is summarized in Chapter 4.0.

Appendix A lists the detailed cask-handling steps for at-reactor cask loading and the data collected for each step. Appendix B presents the data collection forms and the in-transit data collected during the shipment. Appendix C presents the calculations of exposures to the public, both in-transit and during stops, and Appendix D provides dose information from hot-shop unloading of the TN-8L cask.

2.0 CASK LOADING AT REACTOR

Handling times based on multiple cask loadings and personnel exposure calculations using measured and predicted dose rates were completed for the loading of the TN-8L shipping cask at the Surry Power Station by Virginia Power personnel. Loading operations, handling times, and personnel requirements are presented in Section 2.1. Personnel exposure resulting from shipping-cask loading operations are presented in Section 2.2.

2.1 REACTOR CASK HANDLING

As part of the NRC certification process for the TN-8L shipping cask, a generic handling procedure for both cask loading and unloading was developed. The loading portion of this generic procedure was used to develop Surry Operations Procedure OP-4.3. This procedure was then tested in a training exercise and simulated loading, and further refinements were made. This final draft of OP-4.3 was then reviewed and approved by Transnuclear, Inc.; Surry Power Station Quality Assurance Personnel; and the Station Nuclear Safety and Operating Committee.

Cask-handling facilities at Surry Power Station are described in Section 2.1.1. Cask-handling operations are summarized in Section 2.1.2, and staff requirements are outlined in Section 2.1.3. Cask-handling times are discussed in Section 2.1.4.

2.1.1 Surry Nuclear Power Plant Cask-Handling Facilities

A top view of the cask-handling facilities at Surry Power Station is provided in Figure 2.1. Cask-handling facilities consist of the Crane Enclosure Area, the Decontamination Building, and the Fuel Building. After the shipping cask and transport vehicle arrive at the main vehicle gate, receipt inspections are performed. The cask is then transferred to the Crane Enclosure Area and removed from the transport vehicle in a horizontal position, rotated 90 degrees, and placed into a lifting cradle. The horizontal lift to a lifting cradle is required because the tracks for the overhead crane are perpendicular to the orientation of the parked shipping cask trailer. The tracks are perpendicular because of space limitations on where the truck can

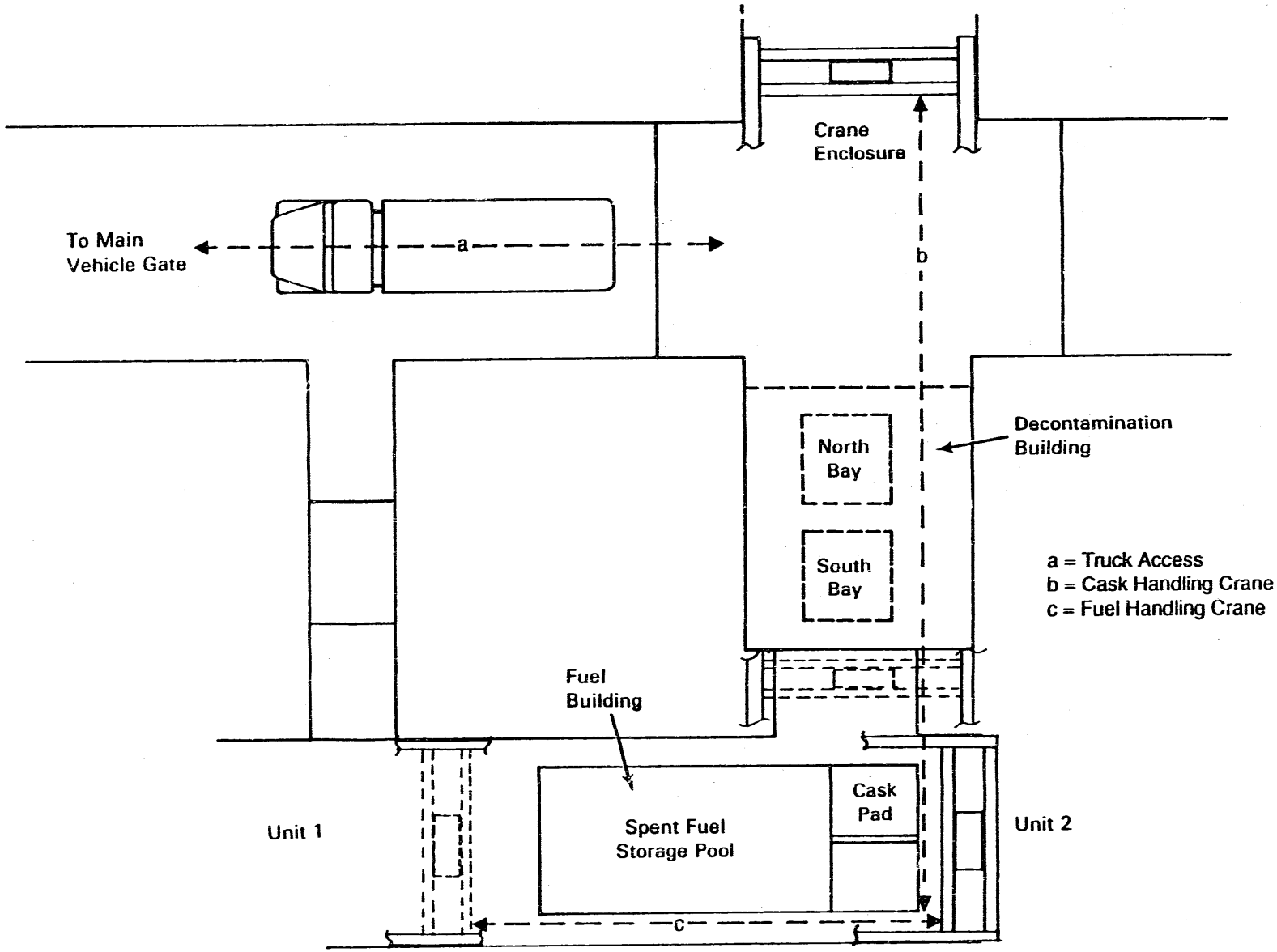


FIGURE 2.1. Cask-Handling Facilities at the Surry Nuclear Power Plant

park. Because the crane must move along the orientation of the horizontal cask in order to upend the cask, the cask can only be removed in a horizontal position from the trailer.

The overhead crane then exchanges lifting yokes, and the cask is upended and transported to one of the bays in the Decontamination Building. After the cask is filled with water and the lid bolts are removed, the cask is moved to the Fuel Building. Inside the Fuel Building, the cask is placed on a submerged cask pad inside the pool for underwater spent-fuel-assembly loading operations. Following loading, the cask is decontaminated in the Decontamination Building and returned to the end of the Crane Enclosure Area for return to the transport vehicle.

For several years before spent fuel shipments were made, a concerted effort was made to improve the handling facilities at the Surry Power Station. These improvements included the following:

1. Enclose the outdoor areas of the 125-ton cask-handling crane to protect against inclement weather.
2. Segregate the cask preparation and testing area in the North Bay of the Decontamination Building with a concrete block wall to reduce background dose from adjacent rad-waste processing equipment.
3. Replace cask set-down pads in the east end of the spent fuel storage pool to mitigate damage to the pool in the event of accidental cask drop.
4. Clean and decontaminate the Fuel Building to allow access by personnel without protective clothing.

2.1.2 Cask-Handling Operations

Detailed cask-handling steps for at-reactor cask loading are provided in Appendix A. Major cask-handling activities are listed and then described below.

1. Conduct receipt inspections, transfer cask and trailer to yard tractor, and enter station to crane enclosure.
2. Remove cask protective and tiedown gear.
3. Perform horizontal lift of cask from trailer to tilting frame.

4. Tilt cask to vertical and lift to preparation area in North Bay of decontamination building.

5. Prepare cask for loading, remove lid bolts, attach protective skirt, and fill cavity with water.

6. Move cask to fuel building.

7. Fill protective skirt with condensate water, and lower cask to bottom of spent fuel storage pool.

8. Load cask with fuel assemblies.

9. Remove cask from pool, install lid bolts, and drain water from protective skirt.

10. Move cask back to preparation area in the North Bay, and dry and decontaminate exposed outer surfaces.

11. Torque lid bolts, drain water from cavity, test for tightness and cavity dryness, and backfill cavity with nitrogen.

12. Remove protective skirt, and check for remaining contamination.

13. Move cask to tilting frame, and tilt to horizontal.

14. Perform horizontal lift of cask from tilting frame to trailer.

15. Install cask protective and tiedown gear.

16. Complete dose rate surveys.

17. Exit station, and transfer to carrier's tractor.

18. Conduct State Police inspection, and Surry Power Station quality assurance (QA) inspection.

19. Complete and sign paperwork.

Activity 1 - Conduct Receipt Inspections, Transfer Cask and Trailer to Yard Tractor, and Enter Station to Crane Enclosure

After the empty shipping cask arrives at the main gate, the cask is surveyed for contamination, and the transport trailer is inspected. The bill of lading is signed, the tractor is disconnected from the trailer, and a yard tractor is connected. After a security search is performed, the cask is moved to the Crane Enclosure Area.

Activity 2 - Remove Cask Protective and Tiedown Gear

At the Crane Enclosure Area, the personnel barrier is rolled back from the cask. The four trunnion impact limiters and the two cask impact limiters are then removed. Two front tiedown binders are released, the trunnion guide assemblies are removed, and the rear tiedown collars are then removed.

Activity 3 - Perform Horizontal Lift of Cask from Trailer to Tilting Frame

The horizontal lift beam is attached to the cask, the cask is moved to the tilting frame, and the lift beam is removed and stored.

Activity 4 - Tilt Cask to Vertical and Lift to Preparation Area in the North Bay of Decontamination Building

The vertical lift beam is attached to the cask, and the cask is upended to the vertical position. The cask is then moved to the Decontamination Building.

Activity 5 - Prepare Cask for Loading, Remove Lid Bolts, Attach Protective Skirt, and Fill Cavity with Water

The bottom cover is attached, the lift beam is unhooked, and the lid system is attached. Holes and rough surfaces are taped over and the protective skirt is attached. Skirt joints are then taped over. The "J" connectors are attached, and the cask is vented to atmospheric pressure. The "A" and "C" port flanges are removed, and the cask is filled with water. The port flange gaskets are checked, and the lid bolts are removed.

Activity 6 - Move Cask to Fuel Building

The lift beam and lid lift system are attached, and the cask is moved to the Fuel Building.

Activity 7- Fill Protective Skirt with Condensate Water, and Lower Cask to Bottom of Spent-Fuel Storage Pool

The skirt fill hose is connected, the cask is lowered into the pool, and the protective skirt is filled. The skirt drain hose is connected, and the fill hose is connected to the water box. The cask is lowered to the bottom of the pool, and the lift beam is released and raised. The lid gaskets are then checked.

Activity 8 - Load Cask with Fuel Assemblies

Three PWR spent fuel assemblies are placed into the shipping cask.

Activity 9 - Remove Cask from Pool, Install Lid Bolts, and Drain Water from Protective Skirt

The lift beam is lowered, the lid is placed on the cask, and the lift beam is attached to the cask. After the cask is lifted to the pool surface, four lid bolts are installed hand tight. The lid lift system and the skirt drain hose are disconnected. The fill hose is connected to a gravity drain, and the cask is lifted, draining the skirt water. The lift beam and the cask are then rinsed with clean water, and the fill hose is disconnected from the cask.

Activity 10 - Move Cask Back to Preparation Area in North Bay, and Dry and Decontaminate Exposed Outer Surfaces

The cask is moved to the Decontamination Building and placed on the floor. The lift beam is disconnected, and the cask is dried and decontaminated.

Activity 11 - Torque Lid Bolts, Drain Water from Cask, Test for Tightness and Cavity Dryness, and Backfill Cavity with Nitrogen

All lid bolts are installed and torqued. Thermocouples are installed, and the lid is tested for tightness. The water in the cask is drained to a floor drain, and residual water is removed by a blow-down of the cavity. The cavity is then tested for dryness. Flange "A" is tested for tightness, and the cavity is backfilled with nitrogen. The cask is checked for contamination, and all tape is removed. Flanges "B," "C," and "D" are tested for tightness, the J connectors are removed, and flanges are installed.

Activity 12 - Remove Protective Skirt, and Check for Remaining Contamination

The protective skirt is removed, and the fins are checked for contamination. The lift beam is then engaged, and the cask is lifted 1 foot. After the cask is lifted, the bottom cover is removed, and decontamination is completed.

Activity 13 - Move Cask to Tilting Frame, and Tilt to Horizontal

The cask is moved to the tilting frame, and the rear trunnion supports on the tilting frame are lubricated. After the cask is lowered in the tilting frame, the lift beam is disengaged and stored. The cask is checked for contamination, dose rates are measured, and the trailer is moved to the center of the Cask Enclosure Area.

Activity 14 - Perform Horizontal Lift of Cask from Tilting Frame to Trailer

The horizontal lift beam is engaged and attached to the cask. The cask is raised above the protective cover and lowered onto the trailer. The horizontal beam is then disengaged and stored.

Activity 15 - Install Cask Protective and Tiedown Gear

The rear tiedown collars and front tiedown binders are installed. The trunnion guide assembly is then installed. The cask impact limiters and the trunnion impact limiters are installed, and the protective cover is rolled out. Security seals are then attached.

Activity 16 - Complete Dose Rate Surveys

A dose rate survey of the cask is completed in the Crane Enclosure Area.

Activity 17 - Exit Station, and Transfer to Carrier's Tractor

The yard tractor pulls the trailer through Gate 1 to the Tri-State Motor Transit tractor. The yard tractor is disconnected, and the Tri-State tractor is connected to the trailer.

Activity 18 - Conduct State Police Inspection, and the Surry Power Station QA Inspection

The State Police and Surry Power Station QA inspections are performed. The rear of the protective cover is then closed, and the cover tiedown cords are attached.

Activity 19 - Complete and Sign Paperwork

After the paperwork is completed, the shipment is released.

2.1.3 Staffing Requirements for Reactor Cask-Handling

Surry Power Station staffing requirements and responsibilities for TN-8L shipments are shown in Table 2.1. Support was provided by Virginia Power corporate staff in the areas of interface with the cask owner and regulatory agencies, fuel selection, scheduling, and problem resolution. A matrix showing the relationship among all the involved parties is shown in Figure 2.2.

Most cask-handling is performed by Surry Power Station operations personnel, formed in a six-man team with a shift supervisor and five operators. Most of the members of the team have Reactor Operator Licenses. The team works one 10-hour shift per day, 7 days a week if needed.

2.1.4 Reactor Shipping Cask-Handling Times

The handling time for each major step is shown in Table 2.2. These data were taken during shipment number 20; therefore, personnel were very familiar with each task and their effectiveness was optimized.

TABLE 2.1. Staffing Requirements

Category	Personnel	Responsibilities
Operations	1 Shift Supervisor 5 Operators	Crane movements, most hands-on work
Quality Control	1 Inspector (part-time)	Calibrate test equipment and tools; cask testing results; verify loading of fuel assemblies; inspect vehicle
Health Physics	1 Assistant Supervisor 1-3 Technicians 2-3 Decontamination Techs. (all part-time)	Conduct dose rate surveys; cask decontamination; housekeeping
Engineering	1 Engineer (part-time)	Resolve problems; schedule vendor interfaces
Security	2 Officers (part-time)	Inspect vehicles; provide station access for vehicles
Construction movements	1 Driver (part-time)	Provide onsite cask and trailer

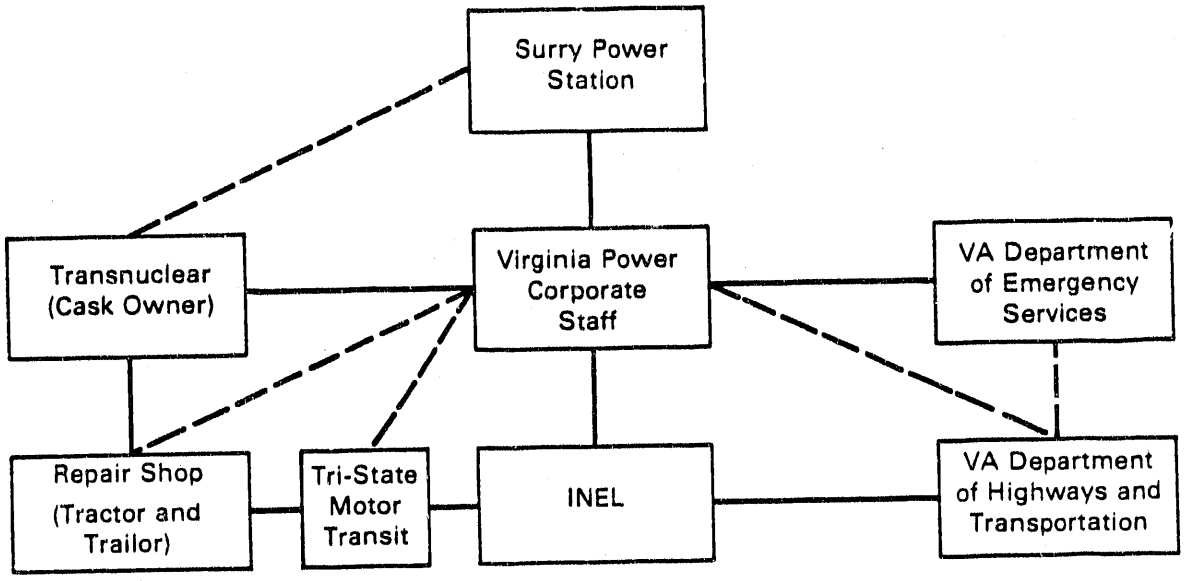


FIGURE 2.2. Organization Matrix for TN-8L Shipments

The total handling time of 14 hours, 7 minutes is the actual handling time and is not the cask turnaround time at the reactor. Total turnaround time, including delays due to equipment and crew unavailability, is shown in Table 2.3, which shows the total time for the 23 shipments. As Table 2.3 shows, total time for shipment number 20 was 3 days.

Improved handling efficiency at the Surry Power Station and at INEL can be observed. Series 2 and 3 were made following the route shown in Figure 1.1. In addition to improving travel time, handling times were improved by up to 50% as personnel became more familiar with cask operations. In some instances, fabrication of customized tools decreased the time needed for particular steps by factors of 4 to 5.

Several shipments were delayed because of problems encountered during loading operations. These problems are summarized below:

- minor malfunction of the 125-ton cask-handling crane
- equipment malfunctions of the carrier's tractor
- minor structural cracks in the trailer
- "weeping" of contamination from the cask

TABLE 2.2. Reactor Shipping Cask Handling Times

	Activity	Elapsed Time (minutes)
1.	Conduct receipt inspections, transfer cask and trailer to yard tractor, and enter station to crane enclosure	92
2.	Remove cask protective and tiedown gear	30
3.	Perform horizontal lift of cask from trailer to tilting frame	15
4.	Tilt cask to vertical and lift to preparation area in North Bay of decontamination building	3
5.	Prepare cask for loading, remove lid bolts, attach protective skirt, and fill cavity with water	115
6.	Move cask to fuel building	20
7.	Fill protective skirt with condensate water, and lower cask to bottom of spent fuel storage pool	60
8.	Load cask with fuel assemblies	10
9.	Remove cask from pool, install lid bolts, and drain water from protective skirt	36
10.	Move cask back to preparation area in North Bay, and dry and decontaminate exposed outer surfaces	22
11.	Torque lid bolts, drain water from cavity, test for tightness and cavity dryness, and backfill cavity with nitrogen	180
12.	Remove protective skirt, and check for remaining contamination	35
13.	Move cask to tilting frame, and tilt to horizontal	47
14.	Perform horizontal lift of cask from tilting frame to trailer	45
15.	Install cask protective and tiedown gear	20
16.	Complete dose rate surveys	15
17.	Exit station, and transfer to carrier's tractor	25
18.	Conduct State Police inspection, and Surry QA inspection	15
19.	Complete and sign paperwork	35
	TOTAL	847

- tearing of the cask protective cover on the trailer
- protective skirt fill and drain hoses snagging on other equipment when lowering or raising the cask from the spent fuel storage pool
- inadequate retraction of the lift beam arms when detaching from the cask
- difficulty attaching shock absorbing covers to the cask
- difficulty coordinating the schedule for different crafts.

Some of these problems were unexpected and could not have been prevented. Others, especially those involving equipment malfunctions, could have been prevented or mitigated by improved inspection and maintenance.

TABLE 2.3. Total Travel and Turnaround Time (days)(a)

	Shipment No.	Load Time	Travel Time	Unloading Time	Travel Time (b)	Total Time
Series 2	8	3.0	3.0	3.0	3.0	12.0
	9	3.0	3.0	2.0	4.0	12.0
	10	3.0	3.0	4.0	2.5	12.5
	11	6.0	3.0	2.0	3.0	14.0
	12	2.5	3.5	1.5	2.5	10.5
	13	3.0	3.0	2.0	2.5	11.5
	14	3.5	3.0	5.0	N/A	11.5
	15	6.5	3.0	2.0	N/A	11.5
	Average	3.8	3.1	2.7	2.9	12.5
Series 3	16	3.0	3.0	3.0	2.5	11.5
	17	3.0	3.0	2.0	3.0	11.0
	18	2.5	3.0	1.5	2.5	9.5
	19	3.0	3.0	2.5	2.5	11.0
	20(c)	**3.0**	**3.0**	**1.5**	**2.5**	**10.0**
	21	4.5	2.5	1.5	2.5	11.0
	22	3.0	3.0	2.0	N/A	8.0
	23	2.5	2.5	3.0	N/A	10.6
	Average	3.1	2.9	2.1	2.6	10.6

(a) Percent Improvement, Series 2 to Series 3 = 15%
(b) N/A = not available.
(c) Shipment followed

Complete "readiness reviews" must be performed to eliminate equipment malfunctions to the extent possible. In particular, vendor-supplied equipment must be inspected and vendor maintenance programs monitored to ensure their adequacy.

Lastly, staff independent of the handling operation are needed to coordinate and monitor vendor activities, to monitor the schedule for incoming, empty casks to ensure personnel readiness, and to coordinate communications with regulatory agencies.

2.2 DOSE EVALUATION OF REACTOR CASK-HANDLING

A cask dose rate map for shipment number 20 is shown in Figure 2.3. The maximum cask surface dose rate for each shipment is shown in Table 2.4. Wide variations in the cooling times, discharge burnups, and number of curies resulted in a comparable wide variation in surface dose rates. Background dose rates for the three working areas are shown in Table 2.5.

Personnel dose by activity is shown by Table 2.6. The loading of the TN-8L cask resulted in 136 person-mrem of exposure. The highest dose producing activity is Activity 11, consisting of all activity steps from torquing lid bolts through backfilling the cavity with nitrogen. Activity 11 contributes 37.00 person-mrem, or 27% of total dose.

Personnel dose by source is shown in Table 2.7. As the table shows, over 72% of personnel dose is from background radiation. Only 38 person-mrem of exposure is from doses received from the cask. Of the 98 person-mrem of exposure received from background radiation, 44% is received in the Decontamination Building, 52% is received in the Fuel Building, and the remaining 4% is received in the Crane Enclosure Area.

Clearly, background dose contributed the major portion of total dose (72%); therefore, efforts to reduce total personnel exposure should be directed towards this source. Background dose can best be reduced by optimizing design efforts to prevent colocation of sources without the proper shielding. Also, good housekeeping and maintenance practices should be stressed to prevent accumulation of background sources. Finally, access to

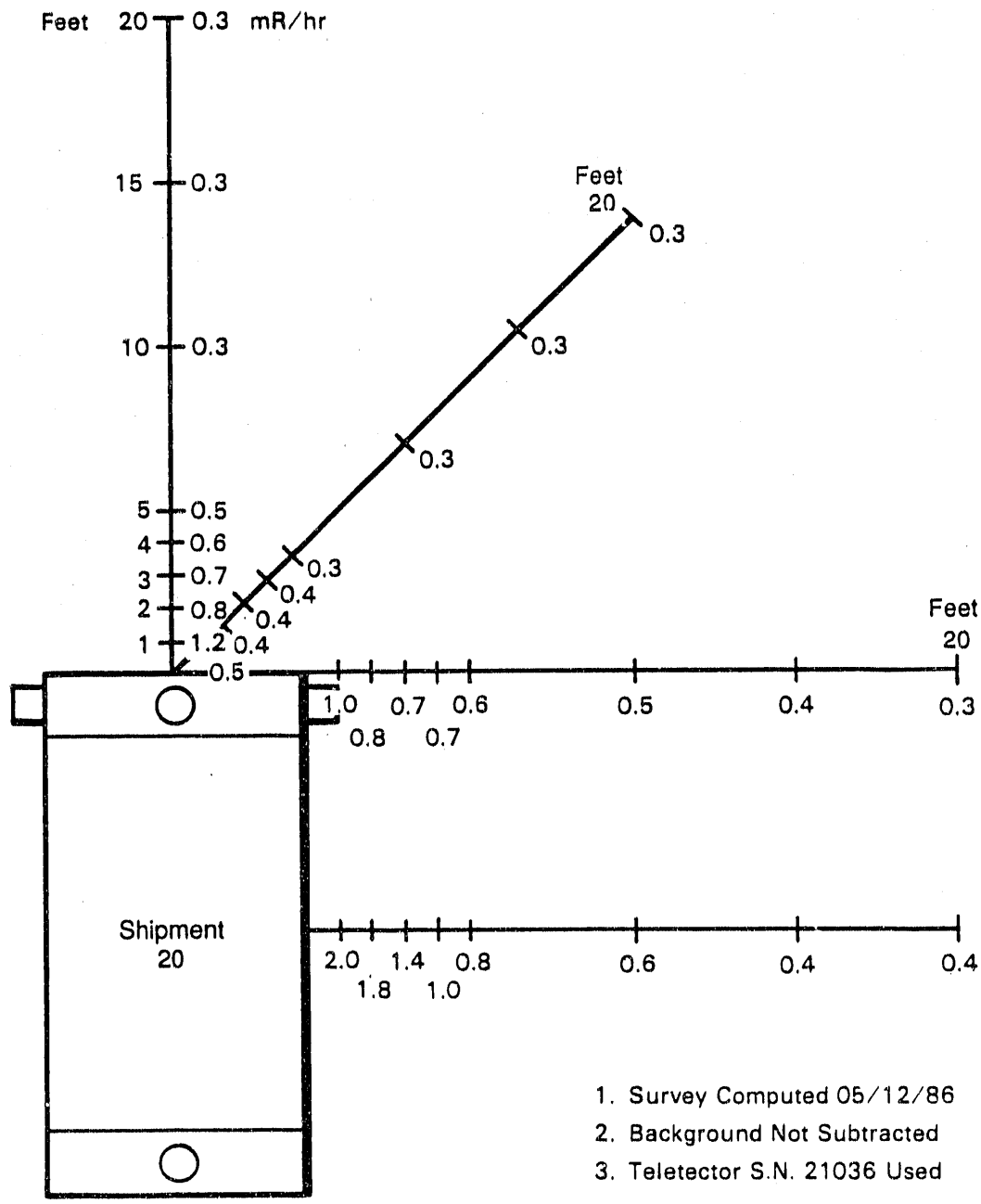


FIGURE 2.3. Cask Dose Rate Map

working areas should be carefully coordinated to ensure that only those persons with tasks to perform are spending the minimum time needed in restricted areas.

TABLE 2.4. Cask Surface Dose Rates[a]

Shipment No.	Cooling Time (yr)	Average Burnup (MWD/MTU)	Activity or Fuel (curies)	Maximum Surface Dose Rate (mrem/hr)
1	3.5	33,000	996,950	13.0
2	3.5	34,000	1.017,000	12.5
3	3.5	33,000	992,900	12.5
4	2.5	32,000	1.426,900	22.5
5	2.5	32.000	1.426,900	22.6
6	2.5	32,000	1,426,900	21.0
7	2.5	32,000	1,426,900	23.8
8	4.0	31,000	876,400	N/A
9	4.0	31,000	85,500	N/A
10	4.0	30,000	847,800	9.8
11	4.0	30,000	845,400	9.8
12	4.0	30,000	845,400	10.0
13	4.0	30,000	839,800	9.0
14	4.0	30,000	839,800	8.4
15	4.0	30,000	839,800	8.2
16	9.0	25,000	459,900	4.0
17	10.0	27,000	464,400	6.0
18	9.0	30,000	536,600	8.0
19	9.0	30,000	536,600	7.0
20	**9.0**	**30,000**	**639,600**	**6.5**
21	7.0	33,000	639,600	10.0
22	4.5	28,000	740,400	6.8
23	7.5	33,000	624,900	8.0

(a) Bold letters indicate shipment followed.

TABLE 2.5. Background Dose Rates

1. Crane Enclosure
   - 0.1 to 1.2 mrem/hr
   - 0.25 mrem/hr average

2. North Bay Decontamination Building
   - 5.0 to 100 mrem/hr
   - 5.0 mrem/hr, top of scaffold around cask
   - 7.0 mrem/hr, floor

3. Fuel Building, Spent Fuel Storage Pool
   - 1.0 to 70 mrem/hr
   - 5.0 mrem/hr, deck around cask-handling area

TABLE 2.6. Personnel Dose by Activity

		Personnel Dose (person-mrem)
1.	Conduct receipt inspections, transfer cask and trailer to yard tractor, and enter station to the Crane Enclosure Area.	0.00
2.	Remove cask protective and tiedown gear.	0.46
3.	Perform horizontal lift of cask from trailer to tilting frame.	0.50
4.	Tilt cask to vertical and lift to preparation area in North Bay of the Decontamination Building.	0.44
5.	Prepare cask for loading, remove lid bolts, attach protective skirt, and fill cavity with water.	13.40
6.	Move cask to the Fuel Building.	5.33
7.	Fill protective skirt with condensate water, and lower cask to bottom of spent fuel storage pool.	22.27
8.	Load cask with fuel assemblies.	6.67
9.	Remove cask from pool, install lid bolts, and drain water from protective skirt.	22.70
10.	Move cask back to preparation area in North Bay, and dry and decontaminate exposed outer surfaces.	4.70
11.	Torque lid bolts, drain water from cavity, test for tightness and cavity dryness, and backfill cavity with nitrogen.	37.00
12.	Remove protective skirt, and check for remaining contamination.	10.84
13.	Move cask to tilting frame, and tilt to horizontal.	3.18
14.	Perform horizontal lift of cask from tilting frame to trailer.	2.42
15.	Install cask protective and tiedown gear.	4.58
16.	Complete dose rate surveys.	1.13
17.	Exit station, and transfer to the carrier's tractor.	0.00
18.	Conduct State Police inspection, and Surry Power Station QA inspection.	0.00
19.	Complete and sign paperwork.	0.00
		135.62

TABLE 2.7. Personnel Dose by Location

Location	Background Dose (person-mrem)	Cask Dose (person-mrem)	Total Dose (person-mrem)
Crane Enclosure Area (empty)	1.40	0.00	1.40
Decontamination Building (empty)	18.73	0.00	18.73
Fuel Building	51.64	0.30	51.34
Decontamination Building (loaded)	52.54	28.67	23.87
Crane Enclosure Area (loaded)	11.31	8.75	2.56
	135.62(a)	37.72	97.90

(a) Background is 72% of total dose.

3.0 IN-TRANSIT ASSESSMENT

The in-transit data collected during the spent fuel shipment are discussed in this chapter. Included in this discussion is a description of the route followed, in-transit data (e.g., hourly vehicle counts, population zones, etc.), stops data (e.g., type of stop, duration of stop, approximate number of individuals exposed, etc.), and the calculated occupational and public doses.

The shipment departed from the Surry Power Station on April 24, 1986, and arrived at the TAN Facility on April 26, 1986. The total distance traveled was approximately 2807 miles, following the route shown in Figure 1.1. The total time required for this demonstration was approximately 62 hours, including 6.4 hours for stops. The average speed was approximately 50 miles per hour. The special regulations applicable to nonstandard shipments and shipments of radioactive materials that follow the route were discussed in Section 1.2.2.

The following sections discuss observations that were noted during transit (in-transit data) and while the shipment was delayed (stops data). Time delays that were encountered enroute as a result of the escort requirements, 2-hour call-ins, or DOT inspections were recorded and are discussed in the stops-data section.

3.1 IN-TRANSIT DATA

This section discusses the in-transit data collected while the TN-8L shipment was being observed. In-transit data includes data collected while the vehicle was moving. The types of data collected included the total mileage traveled, the various population zones encountered, and the number of vehicles on the road and in rest areas or weigh stations.

The mileage was recorded for each observation (see Appendix B). It was determined that the time of the observation would not be required. The time, if necessary for future studies, can be reasonably estimated based on the average truck speed. Mileage is used in a subsequent section to calculate public doses based on the average number of vehicles per mile and on the

average number of vehicles in rest areas and weigh stations, and to determine the percentage of the total distance for each population zone.

Vehicles traveling in the same direction and in the opposite direction were counted on an hourly basis (Table 3.1). Vehicles that are identified as traveling in the same direction were counted as they passed the TN-8L shipment. No distinction was made during data collection as to whether the vehicle was traveling on a two-lane or four-lane highway. Approximately 95% of the highways traveled had four lanes. Two-lane highways were used in Virginia when leaving the Surry Power Station and at the Utah/Idaho border. The number of vehicles stopped at rest areas and in weigh stations, while the shipment was moving, were also counted. The number of vehicles stopped in the opposing lane was 202 and in the same lane or direction was 274.

The distances traveled through the respective population zones also were recorded (see Table 3.2). It was determined that the rural zone represented populations of 10,000 or less, that the suburban zone represented populations greater than 10,000 and less than 30,000 and that the urban zone represented populations greater than 30,000. Areas exhibiting high population densities, such as office buildings and commercial facilities were also recorded as

TABLE 3.1. Summary of In-Transit Data: Vehicle Counts

Direction of Vehicles	Lanes of Traffic	Number of Vehicles
Vehicles traveling in the same direction	2 or 4	113(a)
Vehicles traveling in the opposite direction	2	168(a)
	4	1510(a)
Vehicles parked in the same direction	2 or 4	274(b)
Vehicles parked in the opposite direction	2	10(b)
	4	192(b)

(a) Summation of the 34 hourly vehicle counts.
(b) Totals for the entire shipment.

TABLE 3.2. Summary of In-Transit Data: Population Zones

Population Zone		Population Density (p/m^2)	Segment Length (m)	Percentage of Total
General public:	Rural	8.50E-06	3.99E+06	88
	Suburban	6.90E-05	4.34E+05	10
	Urban	1.60E-03	8.05E+04	2

urban populations. Table 3.2 shows that 88% of the total miles traveled were in rural zones, 10% were in suburban zones, and 2% were in urban zones.

3.2 STOPS DATA

Data were also collected each time the vehicle stopped at a weigh station, rest area, or truck stop. The types of data collected included the reason for the stop, the date, the mileage, the time in and time out or the elapsed time, and general observations, such as the number of vehicles or people in the immediate area. Sketches were also made of representative stops showing the locations and distances of occupied buildings, and other vehicles with respect to the TN-8L shipping cask.

Data were collected on Stops Data Sheets, which are shown in Appendix B (Section B.3). The data are summarized in Appendix B and Table 3.3. Twenty-six stops were made in the 62-hour period for a total of approximately 6 hours, 24 minutes.

In-transit stops represent the greatest potential for dose reductions to the public; therefore, the following sections will discuss each type of stop identified in Table 3.3.

3.2.1 Weigh Stations

Nine stops were made at weigh stations. The total elapsed time for these nine stops was approximately 1 hour, 26 minutes. These stops included a 45-minute stop at the Tennessee border and one stop at a toll booth. The extended stop at the Tennessee border was the result of the Tennessee State DOT inspection of the tractor and trailer, a requirement discussed in Section 1.2.2.

TABLE 3.3. Summary of Stops Data

Category of Stop	Number of Stops	People at Stops[a]	Vehicles at Stops	Avg. Hours at Stops
Weigh Station	9	2	33	0.08
(Tenn. DOT)[b]	1	1		0.75
[c]	1	1		0.05
Rest Area	5		49	0.13
Truck Stops[d]	9	284		0.41
Other vehicles fueling			2	
Other vehicles parked			31	
Badge House	2	5		0.29

(a) People in vehicles not included.
(b) Tennessee DOT Inspector.
(c) Vehicle inspection.
(d) A restaurant stop.

The actual time required to weigh the vehicle was approximately 2 minutes. The remaining time included waiting in line, waiting for the escort vehicle in Wyoming, or waiting to obtain state highway permits. A typical weigh station is shown in Figure 3.1.

3.2.2 Rest Area

The truck drivers were required by contract to periodically "call-in" to a central office and report the location of the shipment. The truck was equipped with a mobile phone, and "call-ins" were normally made in transit. However, "dead spots" or areas not servicing mobile communications were encountered. In these "dead spots," the driver had to stop to complete the "call-in." If possible, these calls were made during refueling, at weigh stations, or at rest areas. Three stops were made specifically to "call-in" and required less than 3 minutes each or a total of 8 minutes. Because of the severe weather conditions in Oklahoma, an extended rest stop (20 minutes) was made to obtain an updated weather report.

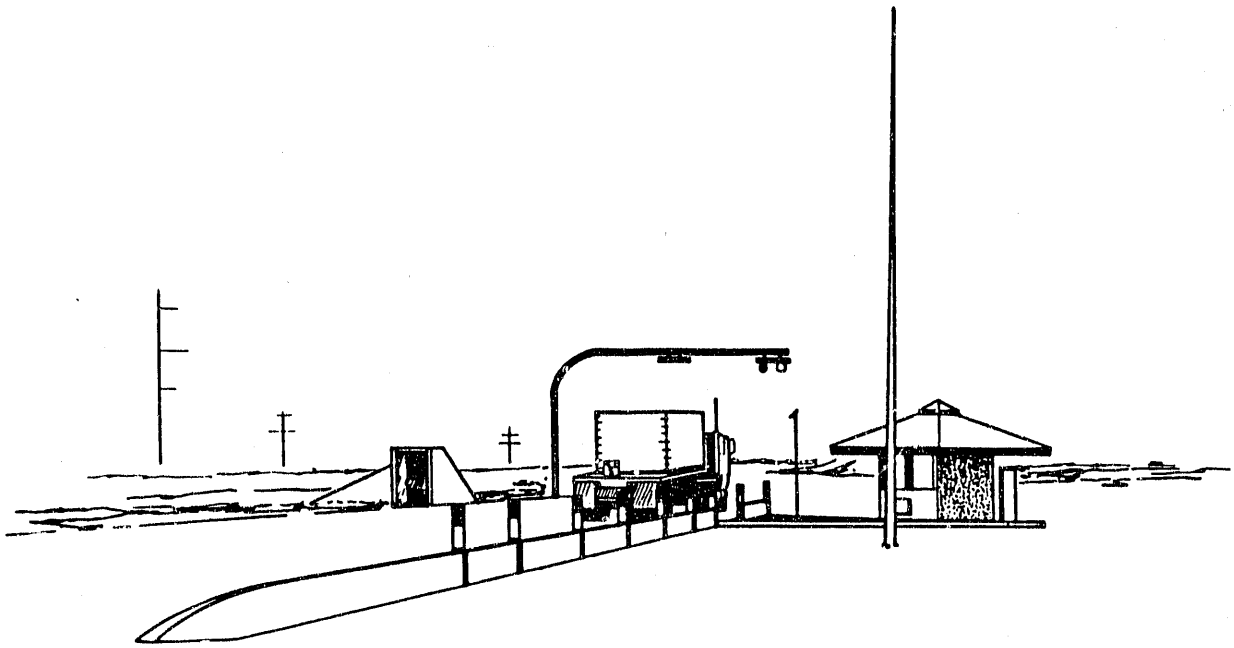


FIGURE 3.1. Typical Weigh Station

3.2.3 Truck Stops

Eight refueling stops were made enroute from the Surry Power Station to the TAN Facility at INEL. The total elapsed time for refueling was approximately 3 hours, 25 minutes, including a 60-minute stop to refuel and repair a rear-axle bearing. The truck fuel tanks were filled at each of these stops, which averaged approximately 25 minutes each. At all of these stops, at least one driver was in the immediate vicinity of the shipping cask at all times. A typical refueling stop is shown in Figure 3.2.

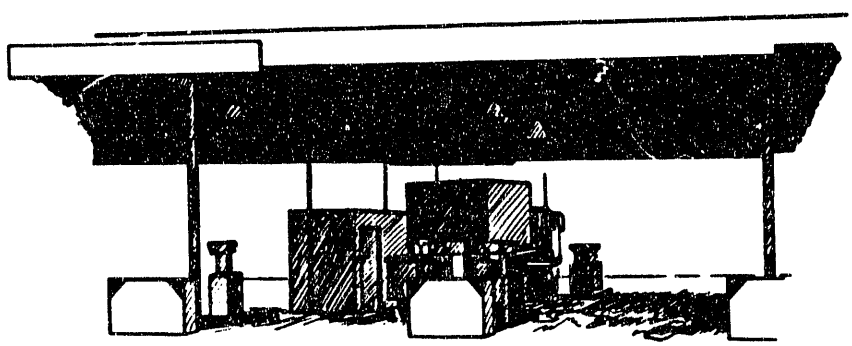


FIGURE 3.2. A Typical Refueling Stop

When available, the drivers used self-service pumps when refueling the truck to reduce shipping costs. At most truck stops, the self-service pumps were located at the furthest islands from the truck stop buildings and overnight parking area. Because the pumps are usually located at the outermost islands, radiological doses to the public inside the truck stops, those parked overnight in their vehicles, and those in queue at the other pump islands were reduced. One of the stops included in the Truck Stops category in Table 3.3 was at a restaurant. This stop required approximately 28 minutes, during which one driver remained with the shipment.

The actual dose received by the public during truck refueling stops is small (see Section 3.3), although the perceived dose to the public during refueling stops is high.

3.2.4 Badge House

It was necessary to stop at the INEL Badge House for about 20 minutes to obtain temporary badges to continue following the shipment to the TAN facility. It was also necessary to obtain temporary badges to enter the TAN facility. This badging process required about 15 minutes. The shipment was then allowed to enter the facility, and the trailer was unhooked from the tractor.

3.3 IN-TRANSIT DOSE EVALUATION

This section presents the estimated dose to the public encountered during the shipment. Included are doses to persons in vehicles traveling in the same direction or in the opposite direction; persons in rest areas, weigh stations, and truck stops; and the general public. The dose to the general public was based on the population densities for each type of population zone encountered. The doses were estimated based on the dose rate maps for a loaded TN-8L shipping cask. The dose rate maps were provided by Virginia Power.

3.3.1 In-Transit Dose Estimates

A description of the detailed dose calculations is provided in Appendix C. These calculations were used to estimate the dose to the public for

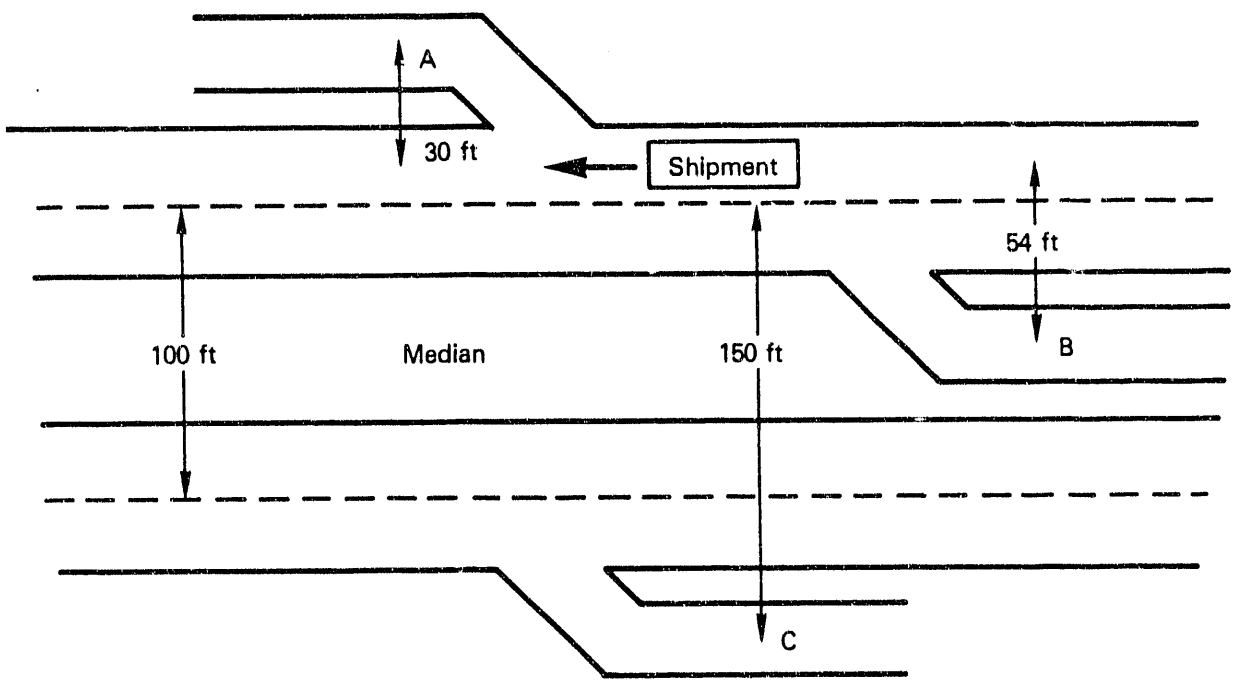
vehicles traveling in the same direction and in opposite direction, and in weigh stations, rest areas, and truck stops.

An average surface dose factor for the sides of the cask was used when performing the calculations. This factor, 10 mrem/hr m^2, is based on the dose rate map provided by Virginia Power and corresponds to a TN-8L cask loaded with three 10-year-old PWR spent fuel assemblies.

Calculated Public Doses

The dose to the public in vehicles encountered during the shipment was calculated using the formula described in Greenborg et al. (1980) and detailed in Appendix C. The distances separating the cask from other vehicles on the highway are shown in Figure 3.3. The distances used to calculate the dose to the public in vehicles are shown in Table 3.4.

Vehicle counts that included vehicles traveling on the interstate or highway and vehicles parked at rest areas or weigh stations were taken during



A - Rest Area or Weigh Station in Same Direction 2 or 4-Lane
B - Rest Area or Weigh Station in Opposite Direction 2-Lane
C - Rest Area or Weigh Station in Opposite Direction 4-Lane

FIGURE 3.3. Typical Dimensions of 4-Lane Interstate (feet)

TABLE 3.4. Distances Used to Calculate the In-Transit Dose to the Public

Location of Vehicles	Distances Used to Calculate Public Doses (feet)	
	Same Direction	Opposing Direction
Two-Lane Highways		
Vehicles encountered	8	8
Weigh stations and rest areas	30	54
Four-Lane Highways/Interstates		
Vehicles encountered	8	100
Weigh stations and rest areas	30	150

the trip. As stated previously, data were not collected on whether the vehicles were traveling on a two-lane or four-lane highway; therefore, the vehicle counts shown in Table 3.5 have been adjusted to reflect the percentage of miles traveled on two-lane or four-lane highways (90% four lane and 10% two lane). To calculate the dose to the public, an average vehicle

TABLE 3.5. Summary of Vehicle Counts Used to Calculate Public Doses

Direction of Vehicles	Lanes of Traffic	Number of Vehicles	Public Exposed[a]
Traveling:[b]			
Same direction	2 or 4	113	158
Opposite direction	2	168	235
Opposite direction	4	1510	2114
Parked:[c]			
Same direction	2 or 4	274	384
Opposite direction	2	10	14
Opposite direction	4	192	269

(a) Based on an average vehicle occupancy of 1.4 persons/vehicle (Greenborg et al. 1980).
(b) In-transit vehicle counts were taken each hour for five minutes.
(c) Total vehicles counted for entire shipment.

occupancy must be determined. For this report, it was assumed that the average occupancy was 1.4 persons per vehicle (Greenborg et al. 1980).

The cumulative dose to the public traveling on a two-lane or four-lane highway was approximately 11.9 person-mrem (see Table 3.6). Approximately 1791 vehicles were involved with an average occupancy factor of 1.4, or approximately 2507 individuals (see Appendix C for detailed calculations).

The cumulative dose to individuals parked at rest areas or weigh stations are also shown in Table 3.6. Approximately 666 individuals were exposed, receiving an accumulative dose of 0.02 person-mrem. Therefore, the total dose received by occupants of vehicles on the interstate at the time of the shipment was approximately 11.92 person-mrem.

Three population zones were identified for this analysis: rural, suburban, and urban. As discussed previously, these zones were identified based on an estimated population. Based on these populations, the following population densities were assigned to each zone:

Rural	8.50E-06 people/m^2
Suburban	6.90E-05 people/m^2
Urban	1.60E-03 people/m^2

These zones are based on the route used for the shipment and have been derived from Rhoads et al. (1986).

Detailed dose calculations, using these population densities, are described in Appendix C. Based on Table 3.6 and the population densities encountered, the total dose to the general public for the entire shipment was 0.40 person-mrem.

Calculated Occupational Doses

Exposure data was not measured for the occupants of the tractor; therefore, occupational doses were calculated using the dose rate map shown in Figure 2.3. Occupational dose was calculated using a dose rate of 0.3 mrem/hr for the crew compartment and the time each individual was in the crew compartment.

TABLE 3.6. In-Transit Dose Estimates for Shipment Number 20

In-Transit Doses	Lanes of Traffic	Vehicles	Population Densities (people/m^2)	Public Dose (person-mrem)
Vehicles traveling in in the same direction	2 or 4	113		11.30
Vehicles traveling in the opposing direction	2	168		0.33
Vehicles traveling in the opposing direction	4	1510		0.25
Vehicles parked in the same direction	2 or 4	274		0.02
Vehicles parked in the opposing direction	2	10		3.0E-04
	4	192		4.1E-03
General public: Rural			8.50E-06	0.07
Suburban			6.90E-05	0.06
Urban			1.60E-03	0.27
Total Estimated Public Dose				12.30
Occupational Dose: Driver				18.6
Second Person				17.3
Total Estimated In-Transit Dose				48.2

Regulations require that one individual remain with the shipment for the entire trip. For this shipment, the individual that remained with the shipment was either in the sleeper or in the passenger seat. It was assumed in this analysis that one person was in the crew compartment at all times and was exposed to the shipment for the maximum time period or 62 hours. The second person was responsible for filling the truck's fuel tanks and ordering meals. The total time the vehicle was stopped for refueling, "rest stops," and meals was 4.35 hours (see Table 3.7); therefore, the second individual was exposed to the shipment, in-transit, for 57.65 hours. The calculated in-transit occupational doses for the person in the crew cab for the entire shipment and the second person were 18.6 person-mrem and 17.3 person-mrem, respectively.

TABLE 3.7. Calculated Doses for In-Transit Stops

Category of Stop	Number of Stops	Number of People at Stops	Number of Vehicles at Stops	Elapsed Time (hours)	Public Dose (person-mrem)
Weigh Station	9	2	33	0.70	0.86
(Tenn. DOT)(a)	1	1		0.75	2.26
(b)	1	1		0.05	0.03
Rest Area	5		49	0.63	0.02
Truck Stops(c)	9	284		3.72	0.37
Other vehicles fueling			2		0.57
Other vehicles parked			31		0.09
Total Estimated Public Dose					4.20
Badge House(d)	2	5		0.58	0.63
Individual Near Shipment(d)(e)	26	1			1.18
Total Estimated Occupational Dose					1.81
Total Estimated Dose					6.01

(a) One Tennessee DOT Inspector.
(b) One vehicle inspection.
(c) Includes one restaurant stop.
(d) Occupational doses.
(e) One person in the vicinity of the cask at all stops.

The total calculated in-transit dose to the public was 12.30 person-mrem, and the total calculated occupational dose was 239.30 person-mrem. Therefore, the total in-transit dose was 251.60 person-mrem (see Table 3.6).

3.3.2 Stops Dose Estimates

Data were also collected each time the vehicle stopped at a weigh station, rest area, or truck stop (see Appendix B, Section B.4). The types of data collected included the reason for the stop, the date, the mileage, the time in and time out or the elapsed time, and general observations (for example, the number of vehicles or people in the immediate area.) This information was used to calculate public dose at each type or category of stop.

Table 3.7 summarizes the data shown in Appendix B, Section B.4, and the calculated doses described in Appendix C.

The total dose to the public for all categories or types of stops was 4.20 person-mrem. The total occupational dose while the truck was stopped was 1.81 person-mrem; therefore, the total public and occupational dose was 6.01 person-mrem (see Table 3.7). The greatest portion of this dose was received by the State of Tennessee DOT Inspector and by one individual that was assumed to be in the vicinity of the shipment at each stop. The Tennessee DOT inspector was categorized as a member of the public, and the dose to this individual, who was in the vicinity of the shipment at each stop, was considered to be occupational dose.

3.3.3 Summary of the Dose Estimates

The total dose received due to shipping one TN-8L shipping cask was the sum of the dose estimates provided in Table 3.8, or 54.21 person-mrem. The total calculated occupational dose was 241.11 person-mrem. The total calculated public dose for the shipment was 16.50 person-mrem. This low dose to the public was the result of the limited number of in-transit stops and the average speed of the shipment, which reduced the number of hours the public was exposed to the shipment.

TABLE 3.8. Summary of Dose Estimates

Persons Exposed to Shipment	People Exposed	Estimated Dose (person-mrem)
Vehicles traveling in the same direction	158	11.30
Vehicles traveling in the opposite direction	2349	0.58
Vehicles parked in the same direction	384	0.02
Vehicles parked in the opposite direction	283	4.4E-03
Rural population zone	8.50E-06/m^2	0.07
Suburban population zone	6.90E-05/m^2	0.06
Urban population zone	1.60E-03/m^2	0.27
Weigh stations	50	3.15
Rest areas	69	0.02
Truck stops	356	2.21
Badge house	5	0.63
Drivers	2	35.9
	Total Calculated Dose	54.21

4.0 DRY CASK UNLOADING

Handling times and personnel exposure resulting from unloading the TN-8L shipping cask at the TAN facility at INEL were obtained by PNL personnel. Unloading operations, handling times, and personnel requirements are presented in Section 4.1. Calculated occupational doses resulting from dry cask unloading operations are presented in Section 4.2. These doses were calculated based on actual time/motion data and exposure data collected by PNL personnel.

4.1 DRY CASK HANDLING

Dry spent fuel assembly transfer from the TN-8L shipping cask to the Westinghouse MC-10 spent fuel storage cask (capacity = 24 PWR spent fuel assemblies) are covered by detailed operating procedures entitled "TAN SFSC Program Fuel Receipt and Transfer from TN-8L Shipping Cask to MC-10 Storage Cask."

The INEL TAN-607 warm and hot shops are described in Section 4.1.1. Cask-handling operations are summarized in Section 4.1.2, and staff requirements are outlined in Section 4.1.3. Cask-handling times are discussed in Section 4.1.4.

4.1.1 TAN-607 Warm and Hot Shops

A top view of the TAN-607 warm and hot shops cask-handling facility is shown in Figure 4.1. The truck arrives and is backed into the warm shop

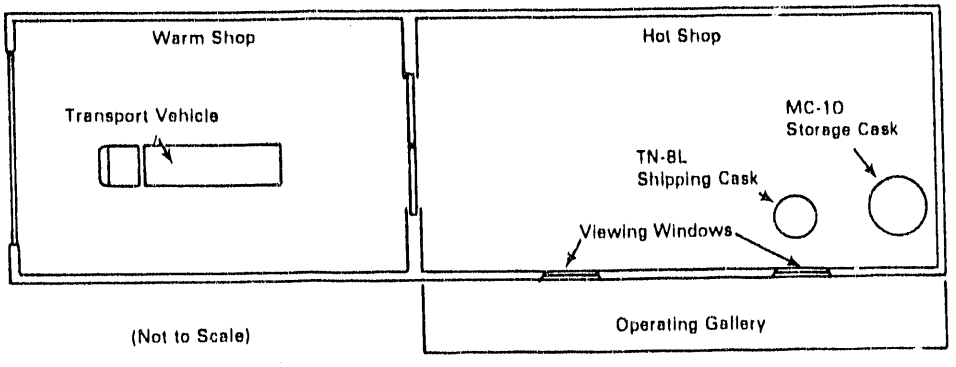


FIGURE 4.1. Top View of the TAN-607 Warm and Hot Shops Cask-Handling Facility

area, as shown by Figure 4.2. Following retraction of the personnel barrier and monitoring activities, the trailer is backed in the hot shop area. A diagram of hot shop shipping cask removal from the transport vehicle is shown in Figure 4.3. The upended shipping cask is then placed adjacent to the

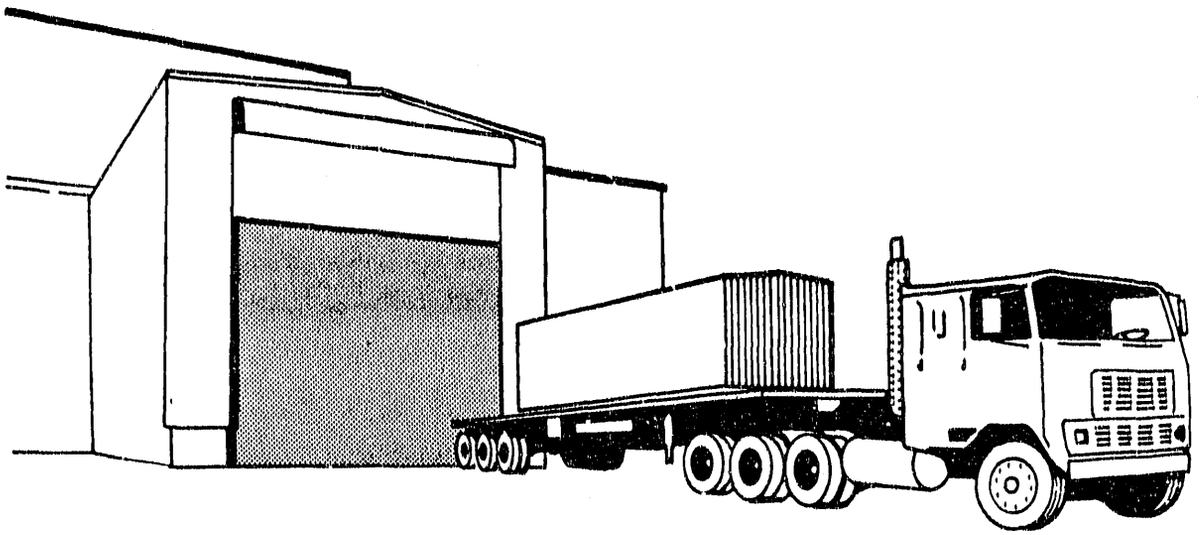


FIGURE 4.2. Truck Backing into Warm Shop Area

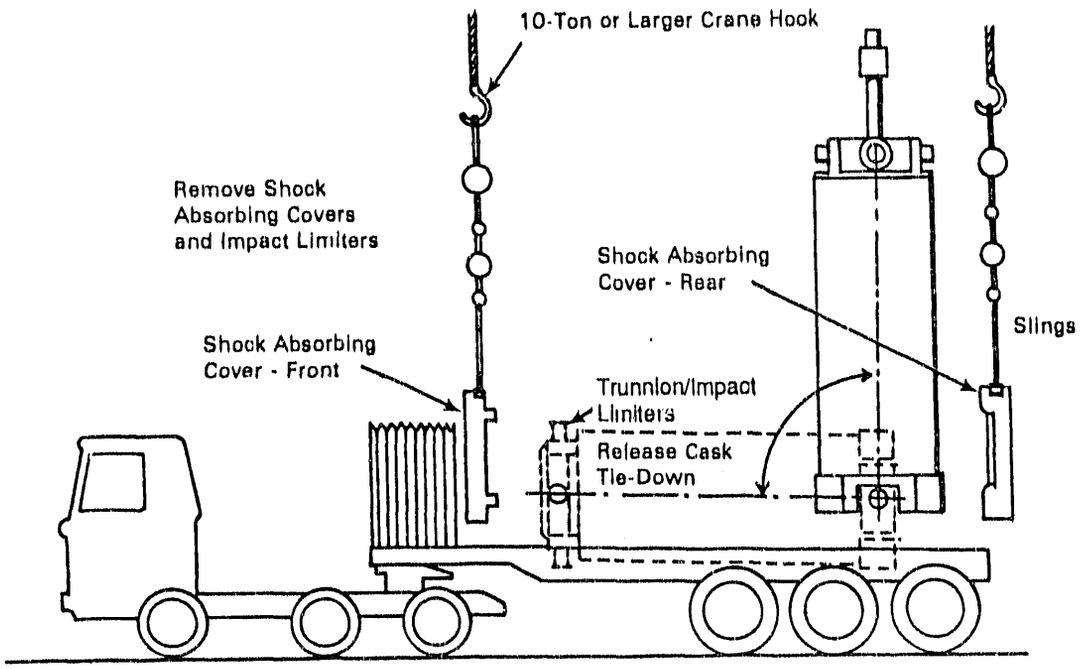


FIGURE 4.3. Hot Shop Shipping Cask Removal from the Transport Vehicle

MC-10 Storage Cask (shown in Figure 4.4) in preparation for fuel transfer. The removable portion of the work platform (Figure 4.5) is then installed to complete the hot shop dual cask workstand, which is shown in Figure 4.6.

All operations are manually performed by operators in the hot shop, with the exception of fuel transfer, which is remotely performed.

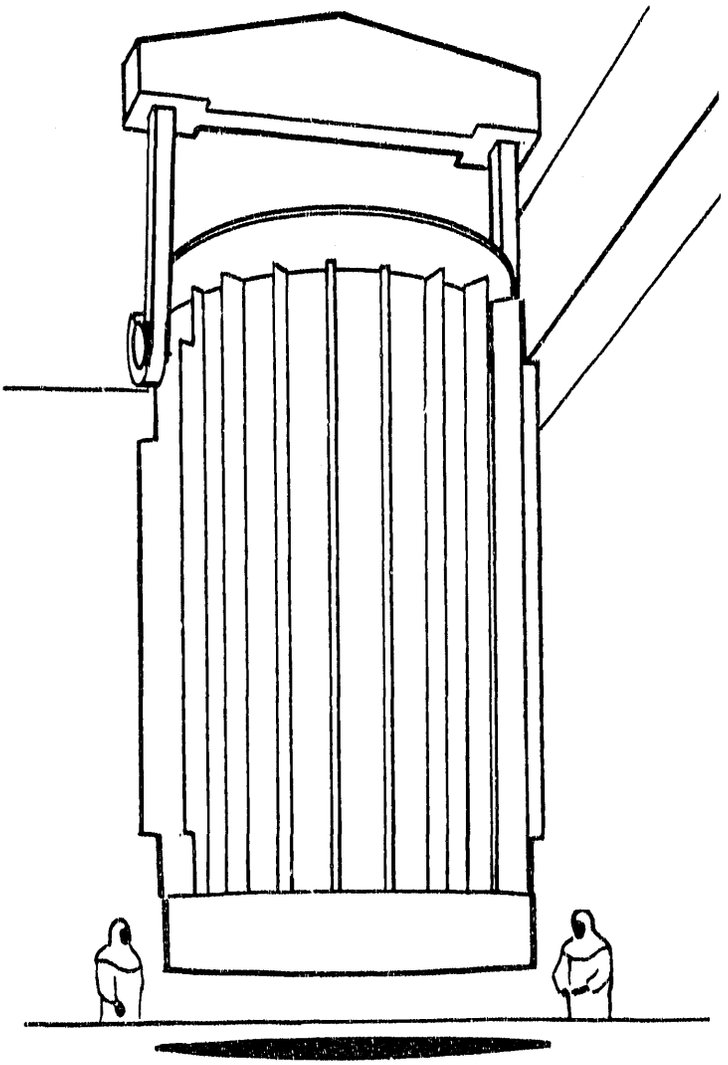


FIGURE 4.4. MC-10 Storage Cask

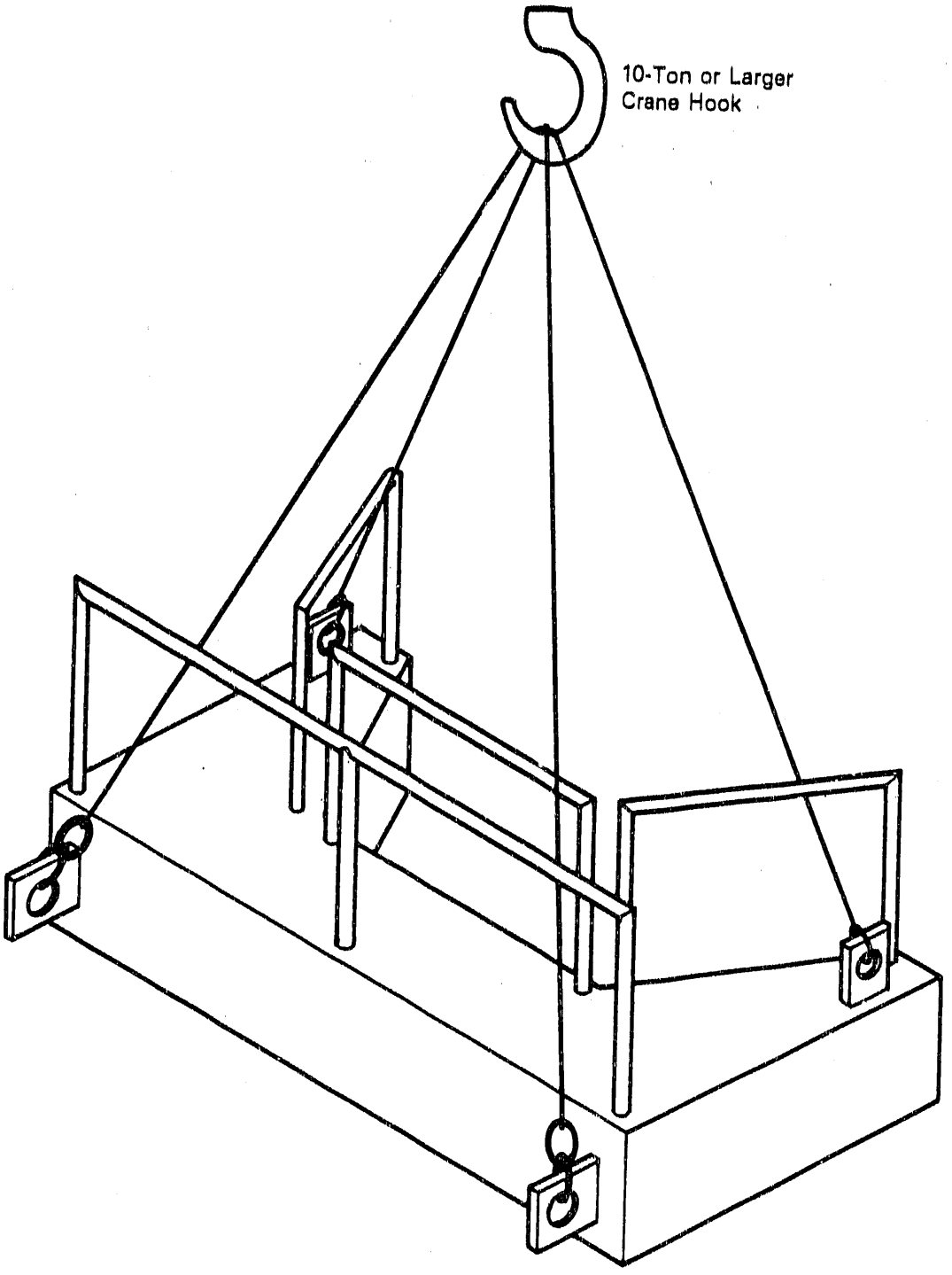


FIGURE 4.5. The Removable Portion of the Work Platform

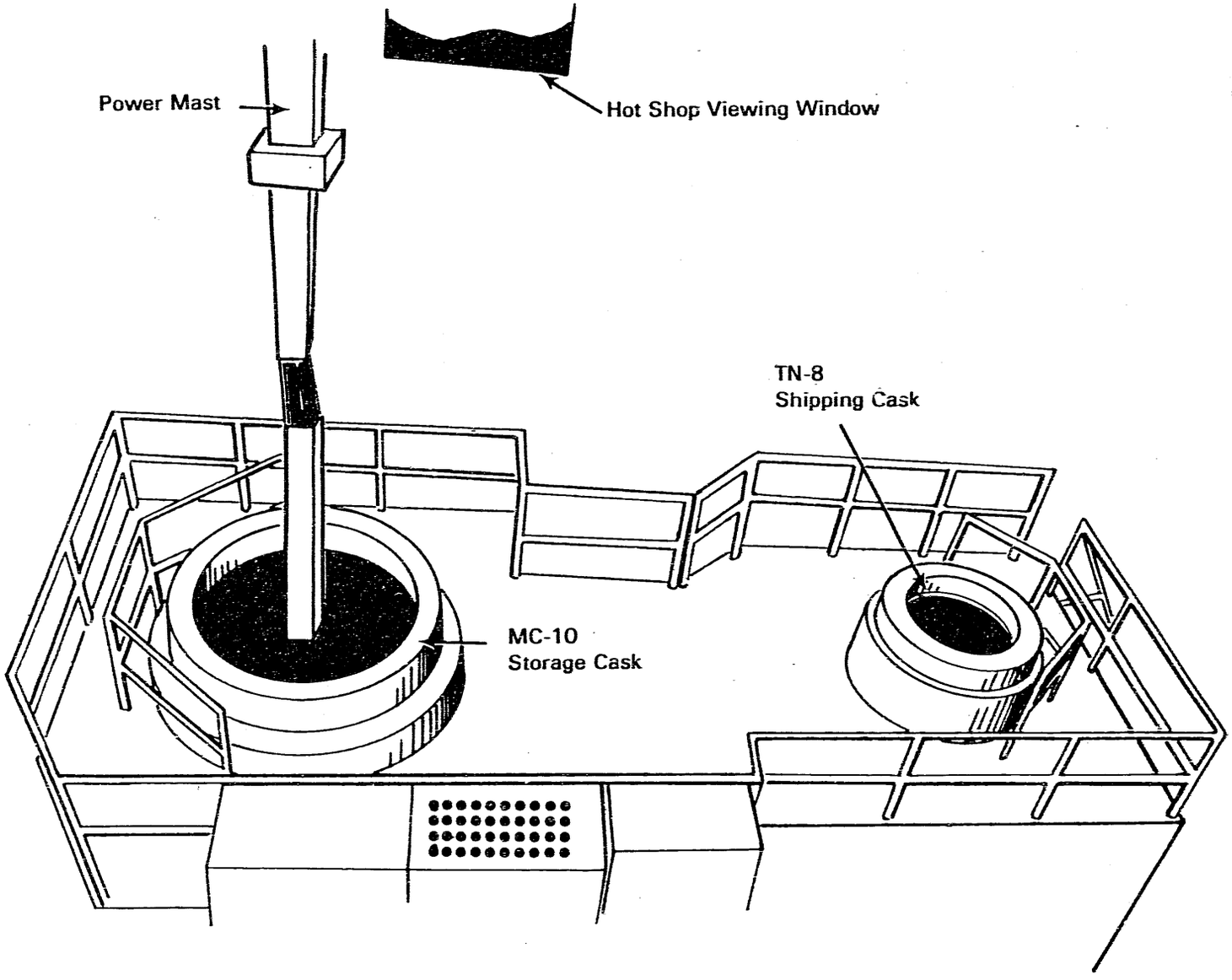


FIGURE 4.6. Hot Shop Dual Cask Workstand

4.1.2 Cask Handling Operations

Detailed cask handling activities for hot cell cask unloading are described in Appendix D. Major cask handling steps are described below:

1. Receive TN-8L cask.
2. Prepare for unloading the TN-8L cask.
3. Prepare the TN-8L cask for fuel transfer.
4. Prepare the MC-10 for fuel transfer.
5. Prepare the TN-8L cask lid for removal.
6. Prepare and verify for remote fuel transfer.
7. Remove TN-8L and MC-10 cask lids and remotely inspect MC-10 lid O-rings.
8. Transfer fuel.
9. Video tape MC-10 basket fuel compartment.
10. Replace MC-10 storage-cask lid.
11. Secure MC-10 storage-cask test lid: perform interim tests or cask tests.
12. Evacuate the MC-10 storage cask and backfill with nitrogen for interim fuel storage, or with helium for testing.
13. Take TN-8L shipping-cask internal smear samples and replace cask lid.
14. Prepare the TN-8L cask for loading onto the shipping trailer.
15. Load the TN-8L shipping cask onto the trailer.
16. Prepare TN-8L shipping cask for return shipment.

Activity 1 - Receive TN-8L Cask

After the loaded shipping cask arrives at the TAN-601 guard station, papers are checked and the shipment is escorted to the warm shop area shown in Figure 4.1. The tarpaulin personnel barrier is retracted and a radiation survey is performed. A vehicle washdown can be performed in the warm shop if required.

Activity 2 - Prepare for Unloading the TN-8L Cask

Plastic is placed down on the hot shop floor, the hot shop door is opened, and the trailer is backed into the hot shop area. Trunnion and cask impact limiters are then removed. The front tiedown, the trunnion guide assembly, and the rear tiedown are then removed. Lifting trunnions are lubricated, and the cask is upended and transferred to the shipping cask work platform. The removal portion of the work platform is then installed. The transport vehicle leaves the hot shop, and the hot shop doors are closed.

Activity 3 - Prepare the TN-8L Cask for Fuel Transfer

Contamination control plastic is placed over the edge of the cask top and around the work platform. A sample cylinder is attached to the gas testing port, and a gas sample and pressure test are taken. If radioactivity is detected in the gas sample, the cask is evacuated before the lid is removed.

Activity 4 - Prepare the MC-10 for Fuel Transfer

The MC-10 storage cask lid is surveyed, and the lid bolts are removed. The lid lifting adapter is then attached to the storage cask lid.

Activity 5 - Prepare the TN-8L Cask Lid for Removal

Cask lid bolts are removed and inspected, the lid lifting adapter is then installed for lid removal, and the hot shop 10-ton crane is attached.

Activity 6 - Prepare and Verify for Remote Fuel Transfer

All equipment is checked and additional contamination control plastic is installed. All personnel leave the hot shop area in preparation for remote operations.

Activity 7 - Remove TN-8L and MC-10 Cask Lids and Remotely Inspect MC-10 Lid O-Rings

With the 10-ton hot shop crane, the TN-8L cask lid is removed and placed on the cask lid support stand. Using a wall mounted power mast, the cask front face metal protective cover is placed on top of the TN-8L shipping cask. The 100-ton crane is then used to lift the MC-10 cask lid for remote

lid O-ring inspection. Following O-ring inspection, the lid is placed on a support stand. The wall-mounted power mast is then used to install the MC-10 surface protector plate.

Activity 8 - Fuel Transfer

The 10-ton crane is remotely connected to the Westinghouse fuel grapple. The crane then moves the grapple to the TN-8L shipping cask where the grapple is engaged to the first spent fuel assembly to be moved. The spent fuel assembly is then placed into the MC-10 storage cask. This process is repeated for three spent fuel assemblies.

Activity 9 - Video Tape MC-10 Basket Fuel Compartment

The MC-10 basket assembly is video taped to verify basket integrity from one unloading to the next.

Activity 10 - Replace MC-10 Storage-Cask Lid

Using the wall-mounted power mast, the MC-10 surface protector plate is removed. The 100-ton hot cell crane then replaces the MC-10 storage cask lid. If radiation levels of airborne particulates are acceptable, personnel enter the hot shop and obtain smear surveys. Contamination control plastic is removed, and the MC-10 lifting lid adapter is unbolted and removed.

Activity 11 - Secure MC-10 Storage-Cask Test Lid: Interim or Cask Testing

Following the torque sequences, MC-10 lid bolts are installed.

Activity 12 - Evacuate the MC-10 Storage Cask and Backfill Nitrogen for Interim Fuel Storage or with Helium for Testing

In parallel with other activities, the MC-10 storage cask is evacuated and backfilled with nitrogen.

Activity 13 - Take TN-8L Shipping-Cask Internal Smear Samples and Replace Cask Lid

Smear samples are taken and the metal front face cover protector removed using the wall-mounted power mast. The lid is then installed with the 10-ton hot shop crane, and the lid lifting adapter is removed. Following the torque sequence, lid bolts are installed.

Activity 14 - Prepare the TN-8L Cask for Loading onto Shipping Trailer

All flanges are replaced, and the cask is surveyed for radiation and decontaminated as required.

Activity 15 - Load the TN-8L Shipping Cask onto Trailer

With the 10-ton hot shop crane, the removable portion of the work platform is removed. The truck and trailer are backed into the hot shop area. The TN-8L cask is then lifted by the 100-ton crane and lowered onto the transport trailer. Front and rear tiedowns are then installed.

Activity 16 - Prepare TN-8L Shipping Cask for Return Shipment

The cask ends are surveyed and decontaminated as required. The impact limiters are installed on the trunnions and on the cask ends. A contamination survey is then completed on the trailer, and the trailer is decontaminated as required. The truck then moves into the warm shop area, and security seals on the front and rear impact limiters are installed. The personnel barrier protective enclosure is then installed, and a final contamination survey is performed. The paperwork is completed, and the transport vehicle and cask are released.

4.1.3 Cask-Handling Staffing Requirements at the TAN Facility

The observed cask unloading at the TAN facility was performed by one shift that was held over until unloading operations were completed. Although many individuals were observed participating in cask-handling activities, a core group of five individuals (excluding truck drivers) were needed to complete cask-handling activities. This essential core group consisted of one health physics individual and four operators/technicians.

4.1.4 TAN Facility Cask-Handling Times

The handling time for each major step is shown in Table 4.1. The total handling time of 8.2 hrs is the actual handling time and is not the cask turnaround time at the TAN facility. Actual cask turnaround time was approximately 16 hours. Delays that were encountered included a lunch break, a brief power failure, a staff meeting, and a load cell indicator failure for the 10-ton hot shop crane. The load cell indicator failure occurred during

TABLE 4.1. TAN Facility Shipping-Cask Handling Times Activity

		Elapsed Time (minutes)
1.	Receive TN-8L cask.	39
2.	Prepare for unloading TN-8L cask.	74
3.	Prepare the TN-8L cask for fuel transfer.	29
4.	Prepare the MC-10 for fuel transfer.	Parallel Activity
5.	Prepare the TN-8L cask lid for removal.	12
6.	Prepare and verify for remote fuel transfer.	28
7.	Remove TN-8L and MC-10 casks remote lid.	56
8.	Transfer fuel.	33
9.	Video tape MC-10 basket fuel compartment.	Not Observed
10.	Replace MC-10 storage cask lid.	34
11.	Secure MC-10 storage cask test lid: interim or for cask testing.	Not Observed
12.	Evacuate the MC-10 storage cask and backfill with nitrogen for interim fuel storage or with helium for testing.	Parallel Activity
13.	Take TN-8L shipping cask smear samples and replace lid.	59
14.	Prepare the TN-8L cask for loading onto shipping trailer.	10
15.	Load the TN-8L shipping cask onto trailer.	41
16.	Prepare TN-8L shipping cask for return shipment.	78
		493 (8.2 hours)

the lifting of the first spent fuel assembly. The weight of the spent fuel assembly did not register on the load cell indicator in the operating gallery servicing the hot shop. After a technician arrived, the problem was corrected by resetting the digital display, which had not been functioning properly since a brief power failure earlier in the day.

The TAN facility crew was extremely well organized and completed activities in parallel whenever possible. From observing the TAN facility crew, it is apparent that even when using manual cask-handling techniques (i.e., hand wrenches, etc.), a repository cask handling crew could achieve truck cask turnaround times of less than 10 hours, as unnecessary delays (i.e., staff meeting) could be eliminated.

4.2 TAN FACILITY CASK DOSE EVALUATION

Dose evaluation for the TAN facility TN-8L cask unloading was based on observed handling times and the cask dose rate map prepared by Virginia Power (Figure 2.3). General area dose rates were estimates obtained from application of health physics principles, and were assumed to be 0.2 mrem/hr for the warm shop, and 2 mrem/hr-10 mrem/hr for the hot shop. Due to the lack of information, the general area dose rate for the operating gallery was assumed to be zero.

The dose analysis for cask unloading is presented in Appendix D and is summarized by major activities in Table 4.2. Major activities that were not observed were not included in the dose analysis. As shown in Table 4.3, the estimated total dose for TN-8L unloading operations is 130.9 person-mrem. Approximately 96% of total dose is due to background or general area dose, and only 4% of total dose is received from the shipping cask. The highest dose producing activity is Activity 13, which involves taking TN-8L shipping cask smear samples and replacing the lid.

TABLE 4.2. TAN Facility Personnel Dose due to Unloading Activities

Activity	Calculated Doses (person-mrem) Cask Work	Background	Total
1. Receive TN-8L cask.	0.6	0.7	1.3
2. Prepare for unloading TN-8L cask.	1.3	10.8	12.1
3. Prepare the TN-8L cask for fuel transfer.	1.7	24.2	25.9
4. Prepare the MC-10 for fuel transfer.	Not observed		
5. Prepare the TN-8L cask lid for removal.	0.7	6.0	6.7
6. Prepare and verify for remote fuel transfer.	1.0	14	15
7. Remove TN-8L and MC-10 casks remote lid.	0.0	0.0	0.0
8. Transfer fuel.	0.0	0.0	0.0
9. Video tape MC-10 basket fuel compartment.	Not Observed		
10. Replace MC-10 storage cask lid.	0.0	0.0	0.0
11. Secure MC-10 storage cask test lid.	Not Observed		
12. Evacuate the MC-10 cask.	Not Observed		
13. Take TN-8L shipping cask smear samples and replace lid.	0.0	49.2	49.2
14. Prepare the cask for loading onto trailer.	0.0	8.3	8.3
15. Load cask onto trailer.	0.0	8.8	8.8
16. Prepare TN-8L shipping cask for return shipment.	0.0	3.6	3.6
	5.3	125.6	130.9

5.0 REFERENCES

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APPENDIX A

TN-8L CASK HANDLING--REACTOR LOADING

TABLE A.1. TN-8L Cask Handling--Time and Motion Form

Activity	Area	Crew Members Required	Support Members in Area	Time in Area (min)	Average Distance from Cask (ft)	Dose Rate from Cask (mR/Hr)	General Area Dose Rate (mR/Hr)	Cumulative Clock Time (min)	Cumulative Dose from Cask (mR)	Cumulative General Area Dose (mR)
A. Unloading										
1. HP survey for cask contamination	Yard	2	0	45	3	0.00	0.00	45	0.00	0.00
2. QC inspection of trailer	Yard	1	0	10	5	0.00	0.00	45	0.00	0.00
3. Sign bill of lading	Yard	1	0	22	25	0.00	0.00	47	0.00	0.00
4. Tractor leaves trailer and cask	Yard	2	0	10	10	0.00	0.00	57	0.00	0.00
5. Yard tractor attaches to trailer	Yard	2	0	5	10	0.00	0.00	62	0.00	0.00
6. Security search	Yard	3	0	15	10	0.00	0.00	77	0.00	0.00
7. Enter gate; move to C/E	Yard	1	0	15	15	0.00	0.00	92	0.00	0.00
8. Roll back protective cover	C/E	4	2	5	4	0.00	0.25	97	0.00	0.13
9. Remove trunnion impact limiters	C/E	1	0	5	1	0.00	0.25	102	0.00	0.15
10. Remove shock absorbing covers	C/E	3	0	20	2	0.00	0.25	117	0.00	0.40
11. Remove front tie-down binders	C/E	1	0	5	1	0.00	0.25	122	0.00	0.42
12. Remove trunnion guide assembly	C/E	1	0	5	1	0.00	0.25	122	0.00	0.44
13. Remove rear tie-down collars	C/E	1	0	5	1	0.00	0.25	122	0.00	0.46
14. Attach horizontal lift beam to cask	C/E	5	1	10	5	0.00	0.25	132	0.00	0.71
15. Lift cask, move to tilting frame	C/E	3	3	5	10	0.00	0.25	137	0.00	0.83
16. Unhook horizontal lift beam, store	C/E	5	1	5	10	0.00	0.25	142	0.00	0.96
17. Attach lift beam to cask	C/E	5	1	10	10	0.00	0.25	152	0.00	1.21
18. Tilt cask to vertical	C/E	3	0	5	25	0.00	0.25	157	0.00	1.27
19. Move cask to decon building	C/E	1	2	10	15	0.00	0.25	167	0.00	1.40
20. Attach bottom cover	D/B	2	1	2	1	0.00	2.00	169	0.00	1.60
21. Unhook lift beam, attach lid lift system	D/B	2	1	3	25	0.00	0.25	172	0.00	1.63
B. Preparation for Loading										
1. Tape over holes, rough surfaces	D/B	3	0	15	1	0.00	2.00	15	0.00	1.50
2. Attach protective skirt	D/B	3	0	30	1	0.00	3.00	45	0.00	6.00
3. Tape over skirt joints	D/B	3	0	10	1	0.00	3.00	55	0.00	7.50
4. Attach "J" connectors	D/B	2	0	10	1	0.00	3.00	65	0.00	8.50
5. Vent cask cavity to atmospheric pressure	D/B	1	0	15	2	0.00	2.00	70	0.00	9.00
6. Remove "A", "C" ports flanges	D/B	1	0	10	1	0.00	3.00	80	0.00	9.50

TABLE A.1. (contd)

Activity	Area	Crew Members Required	Support Members in Area	Time in Area (min)	Average Distance from Cask (ft)	Dose Rate from Cask (mR/Hr)	General Area Dose Rate (mR/Hr)	Cumulative Clock Time (min)	Cumulative Dose from Cask (mR)	Cumulative General Area Dose (mR)
B. Preparation for Loading (contd)										
7. Fill cask with water	D/B	2	0	25	2	0.00	3.00	95	0.00	12.00
8. Check "A", "C" ports flange gaskets	D/B	1	0	5	1	0.00	2.00	100	0.00	12.17
9. Remove lid bolts	D/B	2	0	15	1	0.00	2.00	110	0.00	13.17
C. Loading										
1. Attach lift beam, lid lift system	D/B	4	2	10	2	0.00	2.00	10	0.00	2.00
2. Move cask to fuel building	D/B,F/B	2	8	10	20	0.00	2.00	20	0.00	5.33
3. Connect skirt fill hose	F/B	3	7	5	10	0.00	4.00	25	0.00	8.67
4. Lower cask into pool, filling skirt	F/B	5	5	10	10	0.00	4.00	35	0.00	15.33
5. Connect skirt drain hose	F/B	3	2	2	10	0.00	4.00	37	0.00	16.00
6. Connect fill hose to water box	F/B	3	2	2	10	0.00	4.00	60	0.00	16.67
7. Lower cask to bottom of pool	F/B	4	6	8	25	0.00	4.00	68	0.00	22.00
8. Release lift beam, raise from pool	F/B	4	6	8	25	0.00	4.00	76	0.00	27.33
9. Check lid gaskets	F/B	1	0	4	25	0.00	4.00	80	0.00	27.60
10. Load fuel assemblies	F/B	5	5	10	25	0.00	4.00	90	0.00	34.27
11. Lower lift beam, lid and attach to cask	F/B	5	5	10	25	0.00	4.00	100	0.00	40.93
12. Lift top of cask to pool surface	F/B	4	6	8	15	0.00	4.00	108	0.00	46.27
13. Install 4 lid bolts hand tight	F/B	1	9	2	0	4.00	4.00	110	0.13	47.60
14. Disconnect lid lift system	F/B	1	9	1	0	4.00	4.00	111	0.20	48.27
15. Disconnect skirt drain hose	F/B	1	9	1	2	2.00	4.00	112	0.23	48.93
16. Connect fill hose to gravity drain	F/B	1	9	1	4	2.00	4.00	113	0.27	49.60
17. Lift cask, draining skirt water	F/B	2	6	12	8	0.00	4.00	125	0.27	56.00
18. Rinse cask, lift beam with clean water	F/B	2	0	0	8	0.00	4.00	125	0.27	56.00
19. Disconnect fill hose from cask	F/B	1	9	1	4	2.00	4.00	126	0.30	56.67
20. Move cask to decon building	F/B,D/B	2	4	5	20	0.00	2.00	131	0.30	57.67
21. Set cask on decon building floor	D/B	2	1	5	5	0.00	2.00	136	0.30	58.17
22. Disconnect lift beam from cask	D/B	2	1	2	5	0.00	2.00	138	0.30	58.37
23. Dry and decontaminate cask	D/B	3	0	10	1	4.00	2.00	148	2.30	59.37

TABLE A.1. (contd)

Activity	Area	Crew Members Required	Support Members in Area	Time in Area (min)	Average Distance from Cask (ft)	Dose Rate from Cask (mR/Hr)	General Area Dose Rate (mR/Hr)	Cumulative Clock Time (min)	Cumulative Dose from Cask (mR)	Cumulative General Area Dose (mR)
D. Testing for Departure										
1. Install and torque lid bolts	D/B	2	0	15	1	4.00	2.00	15	2.00	1.00
2. Install thermocouples	D/B	1	0	5	1	4.00	2.00	20	2.33	1.17
3. Test lid tightness	D/B	1	0	20	1	4.00	2.00	35	3.67	1.83
4. Drain cavity water to floor drain	D/B	2	0	15	2	3.00	3.00	50	5.17	3.33
5. Blow-down cavity of residual water	D/B	2	0	15	2	3.00	3.00	65	6.67	4.83
6. Test cavity dryness	D/B	2	0	30	2	3.00	2.00	95	9.67	6.83
7. Test flange "A" for tightness	D/B	2	0	20	1	4.00	2.00	15	12.33	8.17
8. Backfill cavity with nitrogen	D/B	2	0	10	4	2.00	2.00	125	13.00	8.83
9. Check external contamination, remove tape	D/B	3	0	15	1	4.00	3.00	140	16.00	11.08
10. Test flanges "B", "C", "D" for tightness	D/B	2	0	40	1	4.00	3.00	180	21.33	15.08
11. Remove "J" connectors, install flanges	D/B	1	0	5	1	4.00	3.00	185	21.67	15.33
12. Remove protective skirt	D/B	3	0	20	2	3.00	3.00	205	24.67	18.33
13. Check fins for contamination	D/B	1	0	10	2	3.00	2.00	215	25.17	18.67
E. Preparation for Departure										
1. Engage lift beam, lift 1 foot	D/B	2	0	15	10	0.00	3.00	15	0.00	1.50
2. Remove bottom cover, decon	D/B	2	0	15	2	3.00	2.00	30	1.50	2.50
3. Move cask to tilting frame	C/E	2	4	10	15	0.00	0.25	40	1.50	2.75
4. Lubricate rear trunnion supports	C/E	2	4	2	5	0.00	0.25	42	1.50	2.80
5. Lower cask to tilting frame	C/E	4	2	5	5	0.00	0.25	47	1.50	2.93
6. Disengage lift beam, store	C/E	4	2	5	5	0.00	0.25	52	1.50	3.05
7. Check contamination, dose rates	C/E	4	6	15	3	2.00	0.25	67	3.50	3.68
8. Move trailer to center of C/E	C/E	1	0	2	20	0.00	0.25	69	3.50	3.68
9. Engage horizontal lift beam	C/E	5	1	10	5	0.00	0.25	77	3.50	3.93
10. Attach horizontal lift beam to cask	C/E	5	1	5	3	2.00	0.25	74	4.33	4.06
11. Raise cask above protective cover	C/E	5	1	5	5	0.00	0.25	82	4.33	4.18
12. Lower cask onto trailer	C/E	5	1	5	3	2.00	0.25	87	5.17	4.31
13. Disengage horizontal lift beam, store	C/E	5	1	5	10	0.00	0.25	92	5.17	4.43
14. Install rear tie-down binders	C/E	1	0	5	2	3.00	0.25	97	5.42	4.45

TABLE A.1. (contd)

Activity	Area	Crew Members Required	Support Members in Area	Time in Area (min)	Average Distance from Cask (ft)	Dose Rate from Cask (mR/Hr)	General Area Dose Rate (mR/Hr)	Cumulative Clock Time (min)	Cumulative Dose from Cask (mR)	Cumulative General Area Dose (mR)
E. Preparation for Departure (contd)										
15. Install front tie-down binders	C/E	1	0	5	2	3.00	0.25	97	5.67	4.48
16. Install trunnion guide assembly	C/E	2	0	5	2	3.00	0.25	97	6.17	4.52
17. Install shock absorbing covers	C/E	3	0	20	3	2.00	0.25	117	8.17	4.77
18. Install trunnion impact limiters	C/E	1	0	5	3	2.00	0.25	102	8.33	4.79
19. Roll out protective cover	C/E	4	2	5	3	2.00	0.25	107	9.00	4.91
20. Attach security seals	C/E	1	0	5	2	3.00	0.25	112	9.25	4.93
21. Complete dose rate surveys	C/E	2	0	15	4	2.00	0.25	127	10.25	5.06
22. Move through Gate #1 to TSMT tractor	Yard	1	0	15	15	0.00	0.00	142	10.25	5.06
23. Attach TSMT tractor to trailer	Yard	4	0	10	10	0.00	0.00	152	10.25	5.06
24. State Police, QC Inspection	Yard	2	0	15	10	0.00	0.00	167	10.25	5.06
25. Close rear of protective cover	Yard	2	0	10	5	0.00	0.00	177	10.25	5.06
26. Attach cover tie-down cords	Yard	1	0	10	5	0.00	0.00	187	10.25	5.06
27. Complete and sign forms	Yard	8	0	15	50	0.00	0.00	202	10.25	5.06

Total Cumulative Clock Time 14.12 Hours

C/E--Crane Enclosure
D/B--Decontamination Building
F/B--Fuel Building and Spent Fuel Storage Pool

APPENDIX B

IN-TRANSIT DATA COLLECTION

APPENDIX B

IN-TRANSIT DATA COLLECTION

The data collection forms used and the in-transit data collected during the shipment are presented in this appendix. The following subsections of this appendix describe the data collection forms and the proposed use of the data collected.

B.1 IN-TRANSIT DATA COLLECTION FORM

The forms shown in Figure B.1 were intended to be used for collecting data during the shipment. These forms were attached to the stops data collection forms and were intended to be used between each stop. However, adequate space was not provided for the data, so a log book was used.

B.2 IN-TRANSIT DATA

The in-transit data are shown in Table B.1 and are a compilation of the data entered into the log book. Brief summaries have been provided at the end of the data sheets.

B.3 STOPS DATA COLLECTION FORM

This form, shown in Figure B.2, was used to collect data at each stop during the shipment. This form provided adequate space to enter data and to sketch the location of the shipment, with respect to buildings, other vehicles, and individuals in the immediate vicinity.

B.4 STOPS DATA

These data are shown in Table B.2 and are a compilation of the data entered on each of the stops data collection forms.

IN-TRANSIT DATA SHEET

I General

1. Date: _____
2. Name: _____
3. Route Segment: Origin _____ End-point _____
4. Time at Origin: _____ Time at End-point _____
   or
   Approximate Elapsed Time _____
5. Odometer Reading at Origin _____ Endpoint _____
   of Route Segment

II Specific

1. Approximate population distributions (Record approximate) Distances or Odometer Readings for Each Zone

   Urban: From _____ To _____; From _____ To _____
   Suburban: From _____ To _____; From _____ To _____
   Rural: From _____ To _____; From _____ To _____

2. Note names of large cities (>100,000) traversed and indicate yes or no if bypass was used.

   _____
   _____
   _____

3. Note number of times and durations of heavy traffic conditions (vehicle slows to 40 mph).

   _____
   _____
   _____

4. Note number of times and approximate durations of stops in traffic.

   _____
   _____
   _____
   _____

5. Average number and distance from oncoming lanes (i.e., divided highway or not) _____

   _____
   _____
   _____

6. At several points along the route, count the number of vehicles in the same and opposing lanes of traffic per unit time.

   _____
   _____
   _____
   _____

FIGURE B.1. In-Transit Data Collection Forms

7. Miscellaneous Observations

FIGURE B.1. Continued

TABLE B.1. In-Transit Data

Odometer Reading		Vehicle Count		Rest Area				Population Zones(a)		
In	Out	Same Direction	Opposing Direction	Same Direction	Opposing Direction	Road Crew	Misc.	Rural	Suburban	Urban
42655	42924	14	120	0	23	28	12	261	8	0
42924	43030	37	281	10	16	29	0	87	19	0
43030	43044	0	56	5	3	0	0	1	10	3
43044	43224	9	125	11	8	0	0	127	47	6
43224	43291	0	8	0	0	0	0	49	16	2
43291	43452	2	43	12	6	0	0	128	28	5
43452	43626	7	77	79	50	0	0	148	13	13
43626	43784	6	173	9	12	43	0	144	8	6
43784	43962	3	214	4	39	4	21	159	19	0
43962	44196	11	119	26	15	50	0	214	20	0
44196	44286	4	143	0	0	0	0	79	8	3
44286	44492	4	45	56	0	0	0	187	16	3
44492	44713	0	0	27	6	0	0	211	10	0
44713	44858	1	54	17	14	0	0	126	9	10
44858	44961	1	33	2	3	0	0	102	1	0
44961	45072	0	0	4	4	0	0	107	4	0
45072	45171	4	69	1	0"	0	0	92	7	0
45171	45362	3	57	11	3	0	0	179	12	0
45362	45462	7	61	0	0"	0	0	87	13	0

STOPS DATA SHEET

I GENERAL

1. Date _____

2. Name _____

3. Time In: _____ Time Out: _____ Estimated or Elapsed Time _____

4. Reason for Stop:
   a. Refuel
   b. Food
   c. Rest
   c. State Inspection - Vehicle Safety
   e. State Inspection - Weight Scales/Permits
   f. State Inspection - Radiological Inspection
   g. Other - specify _____

5. Location: _____

   5a: Urban _____ 5b: Suburban _____ 5c: Rural _____

6. Odometer Reading: _____

II SPECIFIC

1. Draw general layout of stop. Note as closely as possible the following items:

   a. Location of cask-vehicle
   b. Locations of buildings; distance between cask and buildings
   c. Locations of nearest permanent resident; estimate distance to cask
   d. Locations of other parked vehicles
   e. Shielding provided by buildings, structures, etc. (material and thickness)

FIGURE B.2. Stops Data Collection Forms

2. Attach Photographs

3. Activities: Note as closely as possible the number of persons exposed, the exposure distance, and exposure time.

a. Refueling:
Time In: _____ Time Out: _____
Time in Queue: _____ No. of Vehicles in Line: _____
Performed by (Circle One): Attendant(s) or Driver(s)
Estimated distance from cask _____
Remarks: _____

b. Vehicle Safety Inspection

List Items Inspected: _____

Driver(s) Activities/Location _____

Time in Queue: _____
No. of Vehicles Ahead of Cask _____
Estimated Time: _____
Number of Inspectors: _____
Estimated Distance from Cask: _____

Remarks: _____

c. Weight Scales/Permits

Time In: _____ Time Out: _____
or
Elapsed Time (Estimate) _____
Time in Queue: _____
Number of vehicles in front of cask-vehicle _____
Estimated Distance(s) to person(s) _____

Total Number of persons: _____
Driver(s) Activities/Locations: _____

Remarks: _____

FIGURE B.2. Continued

d. Radiological Inspections

Time In: _____ Time Out: _____

or

Elapsed Time (estimate) _____

List activities and approximate times for each _____

_____

_____

_____

List distance from cask for each activity _____

_____

_____

Number of persons involved in inspection _____

Number of persons other than driver(s) and inspector(s) _____

Remarks: _____

_____

_____

e. Rest Stops Only (Biological relief, etc)

Approximate elapsed time _____

No. of persons at stop _____

Distance from cask to persons _____

Remarks: _____

_____

_____

f. Other activities (Describe briefly; include estimates of time, manpower, distance to cask, and driver(s)

_____

_____

_____

_____

FIGURE B.2. Continued

TABLE B.2. TN8L In-Transit Stops Data

STOP NO	DATE	ODOMETER	TYPE	TIME-IN	ELAPSED TIME-MIN.	REASON	COMMENTS
1	4/24/86	XXXXXX	SURRY NPP	N.A.	XXXXX	START	XXXXXX XXXXXXXXXX XXXXXXXXXXX
2	4/24/86	XXXXX	XXXX	XX	X	XXXX	XXXX XXX
3	4/24/86	43077	REST AREA	XXX	XXX	CALL-IN	60 FT FROM BUILDING AVE. 40 FT FROM 5 VEHICLES
4	4/25/86	43289	TRUCK STOP	12:50 PM	50	REFUEL	WITHIN 30 FT FROM VEHICLES IN BAY AREA
5	4/25/86	43488	REST AREA	3:40 AM	4		100 FT AWAY FROM BLDG 50 FT FROM 5 CARS & 10 TRUCKS
6	4/25/86	43856	TRUCK STOP	12:00 PM	23	REFUEL	8 RIGS NEAR TRUCK 50 PEOPLE IN NEARBY RESTAURANT REFUELING & CHECKING DONE AT 12:15
7	4/25/86		WT STATION	12:40 PM	2	STATE INSP-VEHICLE	NO TRUCKS IN LINE 2 TRUCKS IN LOT
8	4/25/86		INS STATION	2:30 PM		STATE INSP-VEHICLE	TEMP. INSPECTION BY 1 PATROL OFFICER, TRUCK WAVED THROUGH 1 VEHICLE AT STOP
9	4/25/86	44084	REST AREA	3:14 PM		CALL-IN	CALLED IN, 12 VEHICLES IN PK. AREA
10	4/25/86	44132	TRUCK STOP	5:45 PM	20	REFUEL CALL-IN	REFUELED AND CHECKED, 3 RIGS BESIDE TRUCK, 15 PEOPLE IN STORE ADJACENT
11	4/25/86		RESTAURANT	7:00 PM	20	FOOD	2 TRUCKS WITHIN 40 FT OF SHIPMENT 20 PEOPLE IN RESTAURANT WITHIN 80 FT
12	4/25/86		TOLL STATION		3	TOLL BOOTH	1 PERSON AT TOLL STATION BOOTH WAS 3 FT FROM TRUCK
13	4/25/86	44222	REST AREA		20	DRIVER SWITCH WEATHER NEWS	6 VEHICLES WITHIN 40 FT
14	4/25/86	44470	TRUCK STOP	12:55 PM	17	REFUEL	6 TRUCKS NEARBY
15	4/25/66		TRUCK STOP	3:26 AM	27	REFUEL	REFUELED AND CHECKED, CALLED IN 2 TRUCKS WITHIN 20 FT, 4 PEOPLE IN STORE 40 FT AWAY

TABLE B.2. (Contd.)

STOP NO.	DATE	ODOMETER	TYPE	TIME-IN	ELAPSED TIME-MIN.	REASON	COMMENTS
16	4/26/86	44636	WT STATION	3:15 AM	8	STATE INSP-WEIGHT	4 VEHICLES IN LINE
17	4/26/86	44775	WT STATION	6:22 AM	11	STATE INSP-WEIGHT	50 FT FROM STATION, OBTAINED PERMITS FOR BY, ARRANGED FOR ESCORT, 4 VEHICLES WENT THROUGH STATION
18	4/26/86		WT STATION, PORT OF ENTRY	7:16 AM	15	STATE INSP-WEIGHT	ON SCALES FOR 1 MIN, SCALE WINDOW 6 FT AWAY, WAITED FOR STATE POLICE ESCORT
19	4/26/86	44865	TRUCK STOP	8:32 AM	8	REFUEL	HEAVY CROWD - 100 INSIDE, 100 VEHICLES OUTSIDE
20	4/26/86	45047	TRUCK STOP	2:20 PM	15	REFUEL	12 VEHICLES WITH 40 FT
21	4/26/86	45178	WT STATION, PORT OF ENTRY			STATE INSP-WEIGHT	10 VEHICLES ON SIDE, 2 PEOPLE IN BOOTH
22	4/26/86	45205	REST AREA	3:45 PM	2	CALL-IN	PHONE IN AND TIRE CHECK 4 VEHICLES WITHIN 40 FT
23	4/26/86		WT STATION, PORT OF ENTRY	4:55 PM	1		NO VEHICLES IN LINE, 1 IN LOT
24	4/26/86	45336	TRUCK STOP	6:20 PM	25	REFUEL	120 FT FROM STORE, 1 TRUCK AT PUMPS, 10 PEOPLE INSIDE, TOUR BUS PULLED IN AS LEAVING
25	4/26/86		WT STATION	7:14 PM(MT)	4		CALLED IN, 1 TRUCK IN FRONT, 3 TRUCKS IN BACK
26	4/26/86	45433	INEL BADGE HOUSE		20		3 GUARDS
27	4/26/86	45456	GUARD HOUSE	9:45 PM(MT)	15		2 GUARDS IN BADGE HOUSE 10 FT AWAY UNHOOKED TRAILER
TOTAL					537		

APPENDIX C

CALCULATION OF IN-TRANSIT AND STOPS EXPOSURES TO THE PUBLIC

APPENDIX C

CALCULATION OF IN-TRANSIT AND STOPS EXPOSURES TO THE PUBLIC

This appendix discusses the methods used to calculate occupational and public doses during the shipment. These analyses utilize the data described in Appendix B and the dose rate maps provided by VEPCO. Exposure data was not measured for the occupants of the truck; therefore, the radiation dose rate of 0.3 mrem/hr, measured at a distance of 20 ft from the end of the cask, is used for calculational purposes. The occupational doses received by at-reactor and INEL cask handlers are discussed in Chapters 2.0 and 4.0.

The routine occupational exposures received by the public have been calculated based on the formula presented by Greenborg et al. (1980, Appendix C). The calculated doses are based on the dose rate map provided by Surry Power Station and the dimensions of a typical two-lane and four-lane highway or interstate (see Figure 3.3). The Surry Power Station dose rates have been used to characterize the spent fuel shipment with respect to the variable value "k" used to calculate the dose to the public. The "k" factor is based on the age of the spent fuel and the shipping cask used.

FORMULA USED TO CALCULATE EXPOSURES TO THE PUBLIC

The following formulas are used to calculate the in-transit dose to the public traveling in vehicles that have passed the shipping cask. These same formulas have been used to calculate the dose to the public at rest areas and weigh stations passed by the truck (i.e., $V_b = 0$).

Dose to travelers in the same direction

$$DTS = \frac{(2kLNT)}{|V_a - V_b|} \cdot I_1(y) \qquad (C.1)$$

Dose to travelers in the opposite direction

$$DTO = \frac{(2kLNT)}{V_a + V_b} \cdot I_1(y) \qquad (C.2)$$

where k = dose factor (mRm m^2/hr) (10 mrem m^2/hr)

L = route segment length (4.52E+06 m)

N = average number of people/vehicle (1.4 passengers/vehicle)

T = traffic count (vehicles/m)

V_a = shipment velocity (m/hr) (average velocity is 5 mi/hr and is assumed to be constant)

V_b = target vehicle velocity (m/hr) (average velocity is 52 mi/hr and is assumed to be constant)

$I_1(y)$ = integral estimating the dose to a moving or stationary target at some distance (y) in feet from the shipping cask (m^{-1}) (see Figure C.1).

The dose to the area normally occupied by the public is dependent on the distance that the normally occupied area is from the shipping cask. The formula used to calculate the dose to the public, based on population densities, is as follows:

$$DTP'' = \frac{(4kPL)}{V_a} \cdot I_2(d) \qquad (C.3)$$

where k = dose factor (mRm m^2/hr) (10 mrem m^2/hr)

P'' = population densities (people/m^2) (Rhoads, Franklin and Lavender 1986)

rural = 8.5E-06 people/m^2
suburban = 6.9E-05 people/m^2
urban = 1.6E-03 people/m^2

L = length of route segment in each population zone (m)

rural = 3.99E+06 m
suburban = 4.34E+05 m
urban = 8.05E+04 m

V_a = shipment velocity (m/hr) (average velocity is 50 mi/hr and is assumed to be constant)

$I_2(d)$ = integral estimating the dose to the edge of each population zone (30 feet) (see Figure C.2).

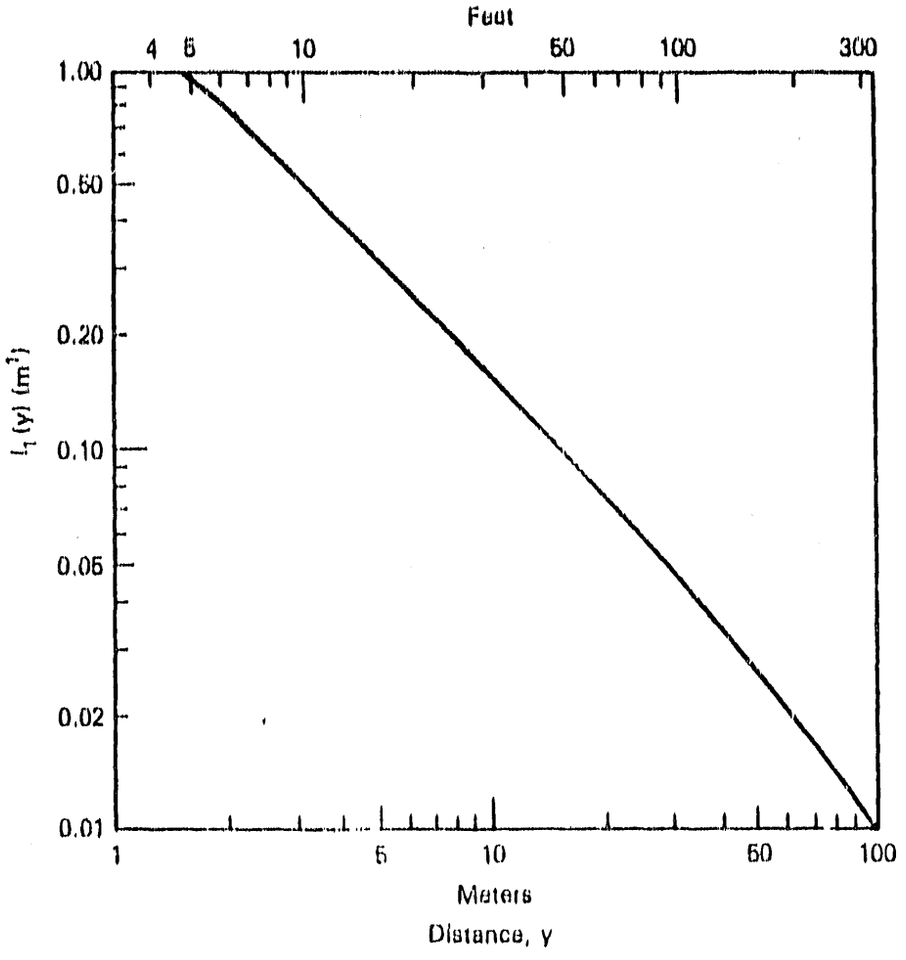

FIGURE C.1. $I_1(y)$ as a Function of y

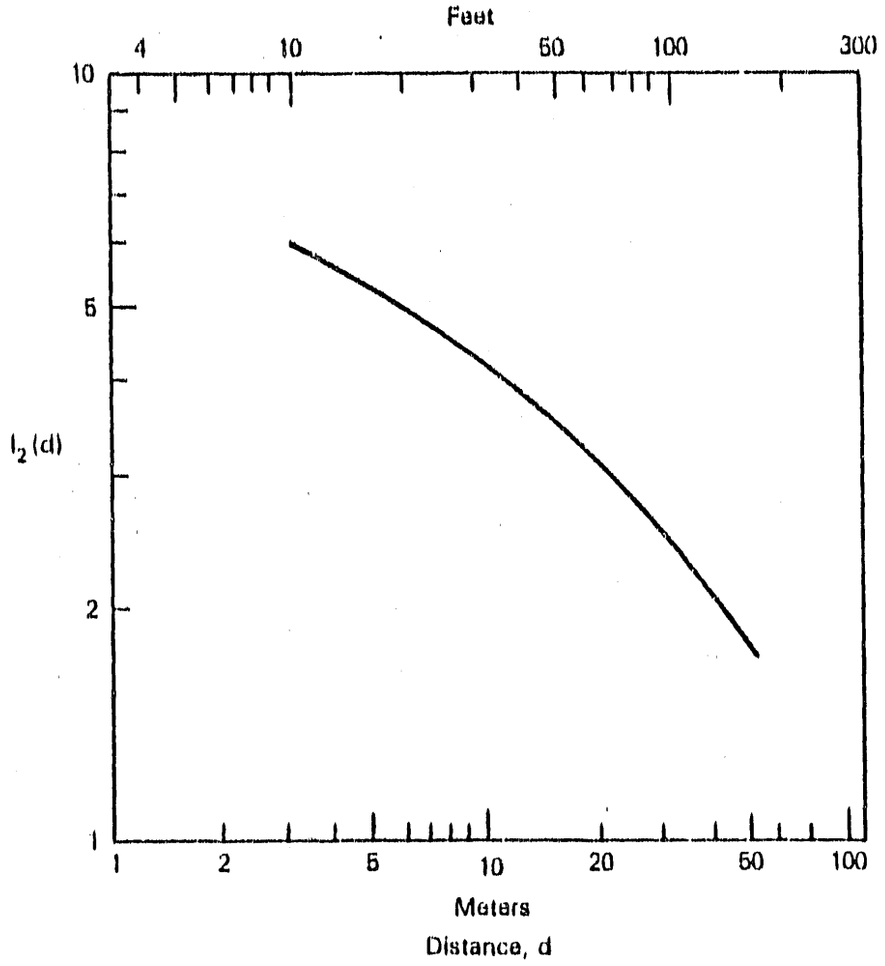

FIGURE C.2. $I_2(d)$ as a Function of d

The shipment stopped 26 times enroute from the Surry Power Station to the INEL-TAN facility. The dose to the public at each of the 26 stops includes the doses received by persons employed at each location, persons in the vicinity of the cask, people eating in restaurants or people stopped at rest areas. The categories or types of individuals exposed at each of the stops have been divided into five categories.

The formula used to calculate the dose to the public for each category of stop is as follows:

Dose to persons in the vicinity of the cask

$$PIV = \frac{(kNTP)}{d^2} \qquad (C.4)$$

where k = dose factor (mRm m^2/hr) (203 mrem m^2/hr)

P = estimated number of individuals at each stop

T = the average time spent at each stop (hr)

N = number of stops per category

V = number of vehicles at each stop

d = distance separating shipping cask and individuals.

In-Transit Dose Calculations

The in-transit public doses have been calculated for occupants of vehicles traveling in the same direction (passing vehicles only, occupants of vehicles traveling in the opposite direction, and occupants of vehicles stopped along the highway or interstate. Three of the previously described formulas have been used to calculate the in-transit public doses. The formulas used and their applications are:

Formula (C.1) To calculate the dose to the occupants of vehicles traveling in the same direction as the shipment and to calculate dose to occupants of vehicles stopped along side the highway or interstate.

Formula (C.2) To calculate the dose to the occupants of vehicles traveling in the opposite direction as the shipment and to calculate dose to occupants of vehicles stopped along side the highway or interstate.

Formula (C.3) To calculate the dose to the general public based on three population densities: rural, suburban, and urban.

Table C.1 presents the data collected and the values used to calculate in-transit public doses.

TABLE C.1. Data Collected for In-Transit Dose Calculations

In-Transit Doses	Lanes of traffic	k (mrem m^2/hr)	N (per./veh.)	P (people/m^2)	T (veh./m)	L (m)	Va (a) (m/hr)	Vb (a) (m/hr)	$I_1(y)$ (m^{-1})	$I_2(d)$ (m^{-1})
Vehicles traveling in in the same direction	2 or 4	10	1.4		113/2.28E05	4.52E+06	80465	83684	0.580	
Vehicles traveling in the opposite direction	2	10	1.4		168/2.28E05	4.52E+06	80465	83684	0.580	
Vehicles traveling in the opposite direction	4	10	1.4		1510/2.28E05	4.52E+06	80465	83684	0.048	
Vehicles parked in the same direction	2 or 4	10	1.4		274/4.52E06	4.52E+06	80465	0	0.160	
Vehicles parked in the opposite direction	2	10	1.4		10/4.52E06	4.52E+06	80465	0	0.085	
	4	10	1.4		192/4.52E06	4.52E+06	80465	0	0.061	
General public: Rural		10		8.50E-06		3.99E+06	80465			4.200
Suburban		10		6.90E-05		4.34E+05	80465			4.200
Urban		10		1.60E-03		8.05E+04	80465			4.200

(a) Velocities are assumed to be constant.

Stops Dose Calculations

Doses have been calculated to the general public in the vicinity of the shipping cask during enroute stops at weigh stations, truck stops, etc. Formula C.4 has been used to calculate the exposure to the general public at these stops. Table C.2 lists the data for each category of stop based on the number of vehicles and the estimated number of people at each stop used to calculate public doses.

Driver Occupational Dose Calculations

Occupational doses were calculated using the rate of 0.3 mrem/hr in the crew compartment. The crew consisted of two truck drivers: a driver and a replacement. It was assumed for calculational purposes that one driver was in the crew compartment for the entire 62 hours and the replacement driver was in the crew compartment for 57.5 hours. It was assumed that 4.5 hours were required for the replacement driver to refuel the vehicle and order meals.

TABLE C.2. Data Used to Calculate Public Doses at Stops

Category of Stop	N (# stops)	k (mrem.m^2/hr)	P (people)	V (vehicles)	T (avg. hrs)	d (m)
Weigh Station	9	2.03	2	33	0.08	1.83
(Tenn. DOT)[a]	1	2.03	1		0.75	0.82
[b]	1		1		0.05	1.83
Rest Area	5	2.03		49	0.13	61.00
Truck Stops[c]	9	2.03	284		0.41	76.20
Other vehicles fueling				2		6.10
Other vehicles parked				31		61.00
Badge House(d)	2	2.03	5		0.29	3.05
Individual near cask[e]	26	2.03	1		0.34	3.90

(a) One Tennessee DOT Inspector.

(b) One vehicle inspection.

(c) Includes one restaurant stop.

(d) These are occupational, but are included in this analysis because of the data collection methods.

(e) One person in the vicinity of the cask at all stops.

APPENDIX D

TN-8L CASK HANDLING--HOT SHOP UNLOADING

TABLE D.1. TN-8L Shipping Cask Unloading

Activity Steps No.	Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Cask Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
1.0	TN-8L Cask Receipt										
1.1	Personnel Barrier Positioned and Secured	0.2	5	5	5	5	3	0.7	0.3	0.1	0.4
1.2	RM Obtains Swipes, Uses Hand Held Monitor	0.2	5	1	18	18	3	0.7	0.2	0.3	0.5
1.3	Check Security Seals,	0.2	5	1	16	16	5	0.5	0.1	0.3	0.4
			Elapsed Time = 39 min						0.6	0.7	1.3
2.0	Preparation for Unloading TN-8L Cask										
2.1	Open Hot Shop Doors (Remote)	0.2	5	0	5	0	-	0.0	0.0	0.1	0.1
2.2	Position Truck in Hot Shop	2	5	0	2	0	-	0.0	0.0	0.3	0.3
2.3	Rear Impact Limiter Removed	2	5	2	9	9	1	1.2	0.4	1.5	1.9
2.4	Front Impact Limiter Removed	2	5	2	7	7	1	1.2	0.3	1.2	1.5
2.5	Remove Rear Trunnion Protectors and Tiedowns, Grease Trunnions	2	5	2	3	3	1	1.2	0.1	0.5	0.6

TABLE D.1. (contd.)

Activity Steps No.	Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Cask Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
2.6	Remove Front Trunnion Protectors and Tiedowns, Grease Trunnions	2	5	2	3	3	1	1.2	0.1	0.5	0.6
2.7	Upend Cask and Remove from Trailer	2	5	2	37	16	3	0.7	0.4	6.2	6.6
2.8	Truck Moves Out of Hot Shop and Hot Shop Door is Closed	2	5	0	2	0	-	0.0	0.0	0.3	0.3
2.9	Radiation Survey of Trailer	2	1	0	6	0	-	0.0	0.0	0.2	0.2
			Elapsed Time = 74 min						1.3	10.8	12.8
3.0	Preparing the TN-8L Cask for Fuel Transfer										
3.1	Install Contamination Control Plastic	10	5	5	5	5	3	0.7	0.3	4.2	4.5
3.2	Perform Gas/Pressure Test	10	5	3	24	24	1	1.2	1.4	20.0	21.4
			Elapsed Time = 29 min						1.7	24.2	25.9
4.0	Preparing the MC-10 for Fuel Transfer										
	Parallel Activity/Not Observed										

TABLE D.1. (contd.)

Activity Steps No.	Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Cask Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
5.0	Preparing the TN-8L Cask Lid for Removal										
5.1	Remove Lid Bolts	10	3	3	9	9	1	1.2	0.5	4.5	5.0
5.2	Install Lifting Adaptor	10	3	3	3	3	1	1.2	0.2	1.5	1.7
			Elapsed Time = 12 min						0.7	6.0	6.7
6.0	Preparation and Verification for Remote Fuel Transfer										
6.1	Install Grapple, Final Area	10	3	3	28	28	3	0.7	1.0	14	15
			Elapsed Time = 28 min						1.0	14	15
7.0	TN-8L and MC-10 Casks Remote Lid Removal										
7.1	Remove Lids Check	0	5		39			0.0	0.0	0.0	0.0
7.2	Install Seal Protector	0	5		17			0.0	0.0	0.0	0.0
			Elapsed Time = 56 min						0.0	0.0	0.0

TABLE D.1. (contd.)

Activity Steps No.	Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Cask Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
8.0	Fuel Transfer										
	#1 SFA Unloaded	0	5	0	13	0	-	0.0	0.0	0.0	0.0
	#2 SFA Unloaded	0	5	0	12	0	-	0.0	0.0	0.0	0.0
	#3 SFA Unloaded	0	5	0	8	0	-	0.0	0.0	0.0	0.0
				Elapsed Time = 33 min					0.0	0.0	0.0
9.0	MC-10 Basket Fuel Compartment Video Taping Not Observed										
10.0	MC-10 Storage Cask Lid Replacement										
10.1	Remove Seal Protector	0	5		10			0.0	0.0	0.0	0.0
10.2	Install Cask Lid	0	5		24				0.0	0.0	0.0
				Elapsed Time = 34 min					0.0	0.0	0.0
11.0	MC-10 Storage Cask Lid Securing Not Observed										
12.0	Evacuate MC-10 Cask Parallel Activity										

TABLE D.1. (contd.)

Activity Steps No.	Activity Steps Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Cask Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
13.0	TB-8L Shipping Cask Smear Samples and Lid Replacement	10	5	1	9	9	3	0.0	0.0	7.5	7.5
13.1	Decontaminate Seal Protector and Remove	10	5	3	14	14	3	0.0	0.0	11.7	11.7
13.2	Spray Plastic, Remove, Swipe Cask Lids	10	5	3	14	14	3	0.0	0.0	11.7	11.7
13.3	Install TN-8L Lid	10	5	2	12	12	1	0.0	0.0	10.0	10.0
13.4	Install Lid Bolts	10	5	2	20	10	1	0.0	0.0	16.7	16.7
13.5	Cover Ports, Torque Bolts	10	5	3	4	4	1	0.0	0.0	3.3	3.3
			Elapsed Time = 59 min						0.0	49.2	49.2
14.0	Prepare the Cask for Loading onto Trailer										
14.1	Decontaminate Cask Bottom	10	5	1	10	10	1	0.0	0.0	8.3	8.3
			Elapsed Time = 10 min						0.0	8.3	8.3
15.0	Load Cask onto Trailer										
15.1	Grease Trunnions, Remove Platform	2	5	3	21	21	2	0.0	0.0	3.5	3.5
15.2	Place Cask on Trailer	2	5	2	20	20	20	0.0	0.0	3.3	3.3
			Elapsed Time = 41 min						0.0	8.8	8.8

TABLE D.1. (contd.)

Activity Steps No.	Description	Area Dose Rate (mrem/hr)	Staff: Total Number in Area	Staff: Number Doing Task Work	Activity Time in Minutes: In Area	Activity Time in Minutes: Near Cask	Work Distance From Cask in Feet	Dose Rate for Cask Work (mrem/hr)	Doses (person-mrem): Cask Work	Doses (person-mrem): Gen. Area	Doses (person-mrem): Total
16.0	Prepare TN-8L for Return Shipment										
16.1	Install Front Impact Limiter	2	5	3	7	7		0.0	0.0	1.2	1.2
16.2	Install Rear Impact Limiter	2	5	3	5	5		0.0	0.0	0.8	0.8
16.3	Install Tiedowns	2	5	2	2	2		0.0	0.0	0.3	0.3
16.4	Install Trunnion Protectors	2	5	2	2	2		0.0	0.0	0.3	0.3
16.5	Check for Contamination, Install Personnel Barrier, Release	0.2	5	5	62	62		0.0	0.0	1.0	1.0
					Elapsed Time = 78				0.0	3.6	3.6

Total Elapsed Time = 493 min
= 8.2 hr

Total Dose = 5.3 person-mrem from cask work

125.6 person-mrem from general area

130.9 TOTAL person-mrem

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