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Letter Report

Irradiated Test Fuel Shipment Plan for the LWR MOX Fuel Irradiation Test Project

October 16, 1998

**L. B. Shappert
L. S. Dickerson
S. B. Ludwig**

Transportation & Packaging Technologies Team
Fissile Materials Disposition Program

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0	10/16/98	Initial version, incorporating comments from reviews by ORNL, DOE/MD, and INEEL.

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L. B. Shappert
L. S. Dickerson
S. B. Ludwig

Oak Ridge National Laboratory

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
for the
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ACRONYMS

ATR	Advanced Test Reactor
CFR	Code of Federal Regulations
CoC	Certificate of Compliance
DOE	U.S. Department of Energy
DOE-AL	DOE-Albuquerque Operations Office
DOE-EM	DOE-Environmental Management
DOE-HQ	DOE-Headquarters
DOE-ID	DOE-Idaho Operations Office
DOE-MD	DOE-Office of Fissile Materials Disposition Program
DOE-OR	DOE-Oak Ridge Operations Office
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
FMCSR	Federal Motor Carrier Safety Regulations
GWd	giga-watt days
HLW	high-level waste
HRCQ	highway route-controlled quantity
INEEL	Idaho National Engineering and Environmental Laboratory
LANL	Los Alamos National Laboratory
LWR	light water reactor
MOX	mixed-oxide fuel
MT	metric ton
n.o.s.	not otherwise specified
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PIE	postirradiation examination
RAP	Radiological Assistance Program
RAT	radiological assistance team
RCO	Regional Coordinating Office
RQ	reportable quantity
SNF	spent nuclear fuel
TBq	terabecquerel
TI	transport index

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1. INTRODUCTION

The U.S. Department of Energy (DOE) is committed to safe, efficient, and cost-effective transportation of all materials that support its various programs and activities. DOE strives to ensure that its radioactive and other hazardous materials, hazardous substances, and hazardous and mixed wastes are handled, packaged, and transported in compliance with all applicable federal, state, tribal, and local regulations.

This document outlines the responsibilities of DOE, DOE contractors, the commercial carrier, and other organizations participating in a shipping campaign of irradiated test specimen capsules containing mixed-oxide (MOX) fuel from the Idaho National Engineering and Environmental Laboratory (INEEL) to the Oak Ridge National Laboratory (ORNL). The shipments described herein will be conducted according to applicable regulations of the U.S. Department of Transportation (DOT), U.S. Nuclear Regulatory Commission (NRC), and all applicable DOE Orders.

This *Irradiated Test Fuel Shipment Plan for the LWR MOX Fuel Irradiation Test Project* addresses the shipments of a small number of irradiated test specimen capsules and has been reviewed and agreed to by INEEL and ORNL (as participants in the shipment campaign). Minor refinements to data entries in this plan, such as actual shipment dates, exact quantities and characteristics of materials to be shipped, and final approved shipment routing, will be communicated between the shipper, receiver, and carrier, as needed, using faxes, e-mail, official shipping papers, or other backup documents (e.g., shipment safety evaluations). Any major changes in responsibilities or data beyond refinements of dates and quantities of material will be prepared as additional revisions to this document and will undergo a full review and approval cycle.

2. BACKGROUND

DOE is supporting a demonstration program to irradiate light-water reactor (LWR) MOX fuel pins containing plutonium from surplus-weapons¹ in the INEEL Advanced Test Reactor (ATR). The purpose of the program is to demonstrate many parts of this mission to dispose of surplus weapons material, including the disassembly of weapons, conversion of the plutonium metal to oxide, fabrication of MOX fuel, fabrication of fuel pins, shipment of the pins to a reactor, irradiation, postirradiation examination (PIE), and, finally, storage of the spent fuel elements awaiting eventual disposition in a geologic repository. The objective of the LWR MOX fuel irradiation tests is to burn laboratory-produced quantities of weapons-grade MOX test fuel in a test reactor under conditions approximately representative of those expected in commercial LWR reactors and then to examine the fuel pellets after irradiation. The LWR MOX fuel irradiation test project is supported by a project team, which includes DOE, Los Alamos National Laboratory (LANL), ORNL, and INEEL.

The LWR MOX fuel irradiation test project has been underway since 1996. In addition to the project plan (Ref. 1), the project team has also prepared a report that describes the expected MOX capsule loading and ATR operations schedule (Ref. 2). The shipment plan for the fresh (unirradiated) MOX fuel from LANL to INEEL was completed in September 1997 (Ref. 3). In December 1997, the initial LWR MOX fuel pins (zircaloy clad) were shipped from LANL to INEEL, thus allowing INEEL to seal the fuel pins in stainless steel capsules and insert the capsules into the ATR to commence irradiation. This test is called the "Average Power Test" or "APT".

Following insertion of the first set of Average Power Test MOX test specimen capsules in the ATR, DOE directed the project team to embark on a second, higher power LWR MOX irradiation test (Ref. 4). This test, called the "High Power Test" or "HPT" would be operated at a higher specific power than the previous irradiation test and would irradiate the MOX fuel test specimen capsules to a greater burnup level. Like the APT, the MOX capsule loading and ATR operations schedule was documented by letter report (Ref. 5). The HPT project plan schedule indicates that the first HPT MOX fuel should begin irradiation in February 1999.

Based on the capsule loading and ATR operation schedules (Refs. 2 and 5), groups of APT and HPT irradiated MOX test specimen capsules will be discharged, and these irradiated capsules will be shipped from INEEL to ORNL to undergo PIE. ORNL and INEEL have the following major responsibilities with regard to the shipment of the irradiated test specimen capsules:

1. ORNL has the lead responsibility for overall project coordination as part of the Reactor Project of the DOE Fissile Materials Disposition Program. To this end, ORNL has developed the pellet and pin specifications, designed and fabricated the irradiation basket, fuel pins, and capsules, predicted the test fuel behavior, and determined the ultimate burnup for the test fuel pins. Once the capsules have been irradiated, ORNL will coordinate with INEEL to ensure the packages chosen to ship the test specimens are compatible with ORNL facilities; ORNL will receive the shipments containing the irradiated test capsules, disassemble the capsules, perform the PIE, package and dispose of the waste materials generated in the PIE, and report the test results.
2. INEEL has the lead responsibility for ensuring that the tests are designed and operated in compliance with all safety and regulatory requirements. INEEL provided specifications, drawings, reactor data, and other guidance, as required, to ORNL to ensure that the design of the test specimens met the requirements of the ATR; is conducting the irradiation of the test specimens; will remove test specimens at prescribed burnups; and will be responsible for the packaging, safeguards and security, emergency planning, notifications, and transportation to ORNL of the irradiated test capsules.

3. PURPOSE OF THE SHIPMENT PLAN

In consideration of the sensitivity and importance of this program, the DOE-Headquarters Office of Fissile Materials Disposition (DOE-MD), as the program office for the LWR MOX test fuel irradiation test project, has mandated a shipment plan for the irradiated test-fuel transport from INEEL to ORNL. This document, *The Irradiated Test Fuel Shipment Plan for the LWR MOX Fuel Irradiation Test Project*, will satisfy that requirement.

This *Shipment Plan* describes the responsibilities of all parties to the transportation functions and contains information describing material types, approximate shipping schedules, estimated number of shipments, modes of transport, proposed routes, packaging descriptions, emergency response, and any security arrangements that might be needed.

4. RESPONSIBILITIES OF ORGANIZATIONS

The complexity of the LWR MOX fuel irradiation test project and the number of supporting organizations mandate that all roles and responsibilities be clearly defined and observed throughout the life of the project. Each phase of the demonstration program has its own planning effort. This document addresses only the responsibilities unique to the transportation phase of irradiated capsules from INEEL to ORNL. The transportation-related responsibilities of the parties are defined below.

4.1 U.S. DEPARTMENT OF ENERGY

4.1.1 DOE-Headquarters (Office of Fissile Materials Disposition – DOE-MD)

The DOE-MD establishes the overall policy for transporting project materials, resolves policy questions, issues guidance, and provides information to use in transportation activities. DOE-MD is responsible for seeking and for arranging funding authority for DOE laboratories and for arranging procurement authorization for other parties.

DOE will provide emergency response teams, including personnel with packaging operations, radiological, and transportation management expertise in the event of a transportation incident or accident. Such assistance is provided by Headquarters, on the request of the state or local emergency response teams, through the DOE Regional Coordination Offices (RCOs). (The two area offices involved in these shipments are the Oak Ridge and Idaho RCOs. A list of all DOE RCOs is provided in Attachment A.)

4.1.2 DOE-Idaho Operations Office (DOE-ID)

DOE-ID is responsible for overall program management for the transfer of irradiated LWR MOX fuel test specimen capsules from INEEL to ORNL. DOE-ID is the shipper of record, and INEEL acts as the agent. DOE-ID has the following responsibilities:

- Approving the shipment of the irradiated test specimen capsules from INEEL to ORNL. The DOE-ID Transportation Program Manager [Miriam R. Taylor, (208) 526-0176] shall have oversight responsibility to ensure that the shipment is conducted in compliance with federal regulations, DOE Orders, and DOE-ID policies.

4.1.3 DOE-Oak Ridge Operations Office (DOE-OR)

DOE-OR is responsible for activities conducted at ORNL, which include receipt of the irradiated test specimen capsules and conduct of the PIE. The DOE-OR Traffic Manager is P. B. Lester (423) 576-8354.

4.2 IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

Items for which INEEL is responsible related to the shipment of irradiated test specimen capsules from INEEL to ORNL are described below.

- Procuring packaging, certified for carrying the appropriate quantities of irradiated MOX, in which to ship the irradiated test specimen capsules and loading the packaging with the irradiated test specimen capsules. The shipment shall meet all applicable DOE and DOT regulations.
- Staging the packaging with adequate time such as to allow for inspection and loading before the scheduled shipping date. All preloading activities (e.g., preparing and testing the loading equipment, preparing procedures for compliance, and scheduling of required support personnel) are the responsibility of INEEL.
- Selecting the carrier. It is preferred, although not required, that the carrier selected be evaluated according to *DOE's Motor Carrier Evaluation Program Plan and Procedures* (Ref. 6).
- Coordinating the schedule for loading and shipping the material with ORNL. The actual schedule will be based on factors such as INEEL's capability to load and ship materials, ORNL's ability to receive the material, predicted weather conditions, and existing road conditions along the route. Should the shipment arrival at ORNL occur outside of normal business hours, INEEL and/or the carrier's dispatch center should contact the ORNL Laboratory Shift Superintendent (LSS) at (423) 574-6606 to arrange access to the ORNL site.

- Making the preshipment notifications, preferred routing information using DOE-approved routing methods (e.g., the ORNL HIGHWAY code), and shipment schedule and updates to the DOE Prospective Shipment Module, DOE-ID, carrier, DOE-OR and ORNL. The notice to ORNL will request authorization to ship on the expected date, will provide a time of expected arrival, name of carrier, and transport identification. Official notification and authorization request will be made to the ORNL Traffic Manager [C. E. Elben, (423) 574-7014, FAX (423) 576-1979]. As a courtesy, INEEL may provide additional notifications of the shipment to: Bldg. 3525 Facility Manager [C. E. DeVore, (423) 576-7713], PIE project manager [R. N. Morris, (423) 241-4237], and the Lockheed Martin Transportation & Packaging Management organization [S. D. McGhee (423) 574-7114].
- Ensuring that radioactive contamination and radiation levels for the package and vehicle are in compliance with the U.S. regulations, through surveys performed on loaded packages and vehicles by qualified, trained personnel using calibrated equipment and following approved procedures.
- Ensuring that all shipping documentation is properly completed, signed, and certified and that all required labeling, marking, and placarding complies with DOT's Hazardous Materials Regulations (49 CFR Parts 171-180) before release of the shipment.
- Providing fissile material quantity information on the appropriate nuclear material transfer form [Form 741]. At ORNL, contact either R. N. Morris at (423) 241-4237 or P. McGill [ORNL Nuclear Material Accountability group, (423) 574-7022].
- Providing the carrier driver with an information packet containing copies of the shipping papers, emergency response information, and special instructions for the shipment before the shipment is dispatched from INEEL.
- Ensuring that the motor carrier is in compliance with the FMCSR (49 CFR Parts 350-399). INEEL will verify the carrier's qualifications, including, but not limited to, driver's qualifications and carrier's equipment, insurance, and state permits, as necessary.
- Approving the carrier's route before shipment and with the prior concurrence of ORNL.
- Ensuring that the motor carrier's vehicle is in compliance with FMCSR, Appendix G, "Minimum Periodic Inspection Standards," (Ref. 7) before loading and that the load is properly secured prior to departure.
- Ensuring receipt of confirmation from ORNL, prior to shipment, that ORNL is prepared to receive the shipment at the planned time and location. The shipment will arrive on the ORNL site at the central receiving area of Bldg. 7001. The ORNL Traffic Manager [C. E. Elben, (423) 574-7014] should be contacted to confirm that ORNL is prepared to receive the shipment from INEEL.

- Meeting the physical protection requirements for transport of this material according to DOE and NRC regulations.

INEEL shall ensure that the selected carrier, under contract to INEEL, meets its responsibilities for safely transporting the irradiated LWR MOX fuel test specimen capsules from INEEL to ORNL. The selected carrier of each shipment has the following responsibilities:

- Installing and properly maintaining the "RADIOACTIVE" placards on the trailer.
- Obtaining required permits and arranging for vehicle inspections along the transportation route, as required by INEEL. (Where practicable, the carrier will work with all regulatory bodies to arrange inspections, as necessary. The carrier will notify the appropriate state vehicle inspection agencies to arrange for vehicle inspections.)
- Providing emergency recovery personnel, equipment (including repair and replacement of tractor or trailer, as necessary), and for procedures in the event of an incident. The carrier has primary responsibility for cleanup and site restoration in the event of an accident.
- Ensuring that: (1) driver training requirements have been met, (2) vehicles meet FMCSR, Appendix G (Ref. 7) inspection requirements before the vehicle is placed in service, (3) vehicles en route satisfy the Commercial Vehicle Safety Alliance Out-of-Service (Ref. 8) criteria, and (4) all other FMCSRs are met.
- Maintaining communication with INEEL via the carrier's dispatch center from departure from INEEL to arrival at ORNL. Any deviation in approved shipment routing, expected arrival times, or unplanned stoppages will be reported to the carrier dispatch center and, through that center, to INEEL, ORNL, and DOE-MD.
- Ensuring that its dispatch center will provide effective communication with the drivers on all extraordinary events involving the shipment, including all known external public relations events that could impact the shipment.

4.3 OAK RIDGE NATIONAL LABORATORY

ORNL, which is the lead laboratory for reactor alternatives for fissile materials disposition, is managing the program for DOE-MD. ORNL is responsible for receiving the irradiated test specimen capsules, disassembling these capsules, performing the PIE, developing the data and other information from the PIE and submitting it to DOE, and disposing of the waste from the examination.

Items for which ORNL is responsible that relate to the shipment of the irradiated test specimen capsules from INEEL to ORNL are the following:

- Preparing the irradiated test fuel shipping plan (this document)
- Notifying INEEL of acceptance of INEEL-prepared shipping schedule and details.
- Coordinating with INEEL to ensure that the shipping packages chosen by INEEL are compatible with the central receiving facilities at ORNL (Bldg. 7001). ORNL will also arrange for the on-site movement of the package from the ORNL central receiving facility to the PIE facility (Bldg. 3525). C. E. DeVore is Facility Manager of Bldg. 3525 [(423) 576-7713]. R. N. Morris is project manager in charge of the PIE activity [(423) 241-4237]. Packaging compatibility questions should be directed to either C. E. Eblen, R. N. Morris, or to S. D. McGhee [Lockheed Martin Transportation & Packaging Management, (423) 574-7114].
- Notifying INEEL immediately upon receipt of material or if there is a delay past the estimated time of arrival or a suspected loss of material.
- Preparing and arranging for transport of the empty shipping package back to INEEL or to another location specified by INEEL.
- Ensuring that radioactive contamination and radiation levels for the empty package and the vehicle are in compliance with the U.S. regulations, through surveys performed on loaded packages and vehicles by qualified, trained personnel using calibrated equipment and following approved procedures.
- Preparing the empty package for return to the custodian at GE Vallecitos Nuclear Center in Pleasanton, California. ORNL will arrange for a separate carrier to transport the empty package back to GE Vallecitos [the custodian at GE Vallecitos is Erin Heinlein (925) 862-4567]. ORNL will provide the carrier driver with an information packet containing copies of the shipping paper, emergency response information, and special instructions before the shipment of the empty cask is returned.

5. SHIPMENT SCHEDULE

This report covers the shipments of the test specimens that have been irradiated as part of the Average Power Test (APT) program and the High Power Test (HPT) program in the ATR.

Average Power Test Shipments. In the case of the APT program, a total of 11 MOX capsules have been or will be inserted in the reactor and will be discharged at three different times (Ref. 2) and sent to ORNL for a PIE; varying the discharge dates will have the effect of varying the

burnup in the capsules from approximately 8 to 30 GWd/MT. Table 1 identifies the number of capsules that will be discharged, projected discharge dates, and the expected burnup of those capsules as part of the average power test irradiation schedule.

Table 1: Average Power Test Capsule Discharge Schedule²

No. of MOX Capsules Discharged	Projected Discharge Date	Average Burnup, GWd/MT
2	Sept. 1998	8
2	Dec. 1999	20
7	Jan. 2001	30

Note: The table above only lists the MOX capsules from each phase of the average power test. Phase III also includes "dummy" capsules that will be shipped with the Phase III MOX capsules to ORNL.

Each set of capsules will be shipped to ORNL in one of three separate shipments shortly after discharge from the ATR. The exact cooling time between when the capsules are discharged and then shipped to ORNL is not fixed, but is expected to be about 30 days. Shielding and heat transfer requirements have been examined for capsules shipped as short as 7 days after discharge.

High Power Test Shipments. In the case of the HPT program, a total of 13 MOX capsules will be inserted in the reactor and will be discharged at three different times (Ref. 5) and sent to ORNL for a PIE; varying the discharge dates will have the effect of varying the burnup in the capsules from 15 to 45 GWd/MT. As in the APT Program, Table 2 identifies the number of capsules that will be discharged, projected discharge dates, and the expected burnup of those capsules. And similar to the APT Program, three shipments of HPT capsules are planned to transfer these irradiated capsules to ORNL.

Table 2: High Power Test Capsule Discharge Schedule⁵

No. of MOX Capsules Discharged	Projected Discharge Date	Average Burnup, GWd/MT
4	Dec. 1999	15
1	Sept. 2000	30
8	Jul. 2001	Four at 30; Four at 45

Note: The table above only lists the MOX capsules from each phase of the high power test. The high power test will also include irradiated control capsules (low-enriched uranium) that will be shipped to ORNL.

Note that at the end of the third cycle of the HPT, eight MOX capsules will be discharged, half of which will have reached an average burnup of about 30 GWd/MT and half that will have achieved an average burnup of about 45 GWd/MT. All eight capsules will be shipped together to ORNL in one cask.

Each set of capsules will be shipped to ORNL shortly after discharge from the ATR. The exact cooling time between when the capsules are discharged and subsequently shipped to ORNL is not fixed, but is expected to be about 30 days.

It may be possible, assuming that the ATR irradiations occur as planned, to combine one or more of the irradiated test specimen capsule shipments into a single shipment. Based on the present planned schedules, the discharge of the 2nd irradiation cycle APT coincides with the discharge of the 1st irradiation cycle HPT.

The estimated travel time for the shipment from INEEL to ORNL is about 34 hours, assuming legal speeds are maintained on highways (see appendix C). Actual shipment time will vary somewhat because of required stops, delays enroute, vehicle servicing, inclement weather, and carrier inspections.

6. ADVANCE AND POST-NOTIFICATIONS AND TRACKING OF SHIPMENTS

Advance notification to the states is not required for these shipments. However, for the irradiated test capsule shipments, INEEL will provide ORNL with advance notification.

The carrier will notify its dispatch center of any unscheduled stops enroute, including stops for inclement weather. Any deviation from the preferred route chosen will comply with applicable state, tribal, and local regulations, and carrier operating procedures.

For the irradiated test capsule shipments, ORNL will notify INEEL (1) on receipt of material, (2) if the shipment has not arrived on time (by end of 1st working day past shipment due date), or (3) if the material is suspected to be lost or otherwise unaccounted for.

7. MATERIAL INFORMATION

The test fuel pins are composed of high-density, sintered, MOX pellets. The pellets were manufactured by LANL from depleted uranium oxide and plutonium oxide according to the technical specifications document (Ref. 9). The pins for the APT consist of zircaloy-tube cladding, with 15 MOX pellets each, and welded end-caps. The pins were then encapsulated in stainless steel tubes with welded-end caps by INEEL before their insertion into the ATR. For the HPT, the pins consist of zircaloy-tube cladding, with 13 MOX pellets each and an upper and lower hafnium-oxide shield pellet, and welded-end caps. The HPT pins, when fabricated, will also be encapsulated in stainless steel tubes with welded-end caps by INEEL before their insertion into the ATR. Figures 1 and 2 shows the configuration of the capsule and test assembly for the APT and the HPT, respectively. Figure 3 shows a detailed view of a "typical" capsule assembly for the APT, with representative dimensions.

Figure 1. Capsule and Test Assembly Configuration – Average Power Test

Figure 2. Capsule and Test Assembly Configuration – High Power Test

Figure 3. ATR FMDP MOX Capsule Assembly Dimensions

Upon discharge from the ATR, each capsule will contain fewer grams of fissile material than when it was inserted, but will contain the fission products that were produced during the irradiation cycle and additional radioactivity due to the neutron activation of the non-fuel components of the MOX capsules (i.e., activation products in the zircaloy and stainless steel structural components). Decay of the actinides, fission products, and activation products produces photons, neutrons, and heat. All decay products have been identified and evaluated.

The thermal output from each capsule is small, generally less than 3 watts after 30 days decay. The penetrating radiation (both photons and neutrons) has been examined, using the ORIGEN-S code, for capsules discharged after each irradiation cycle. Using information generated from the ORIGEN-S code, all significant fission products were considered and evaluated as a function of time after discharge. This information provides the foundation for (a) identifying the radiation source terms for the capsules as a function of time after discharge, (b) determining the proper shielding required to protect workers during handling operations, and (c) evaluating the various packagings that may be used to transport the capsules from INEEL to ORNL.

The activity of the activation products, actinides, and fission products are summarized in Appendix B. Also presented are the quantities of the uranium and plutonium isotopes after irradiation.

Note that the activity for each isotope may change for each shipment depending on the level of irradiation and the actual cooling time between reactor shut down and when the shipment is made. The correct (or maximum) activity for the most significant isotopes being shipped will be provided on the official shipping papers.

8. PACKAGING

The irradiated capsules that will be shipped from INEEL to ORNL contain sufficient quantities of actinides and fission products to exceed Type A limits. Thus, the packaging chosen to ship the material must be a Type B package and have a current Certificate of Compliance (CoC) approved for transporting these types of materials. The choice of packages is the responsibility of INEEL. The packaging must have adequate shielding and sufficient cavity size to accommodate the capsules as they will be shipped.

Two shipping casks are considered candidates for transporting the irradiated fuel capsules to ORNL from INEEL: these are most probably the GE-100 with the GE-2000 as a backup. These packagings are briefly described below. For either candidate package, a simple "handling container" will need to be fabricated to function as a dunnage/shoring to secure and protect the irradiated test specimen capsules during shipment.

INEEL will be responsible for supplying a suitable "handling container" and in acquiring a suitable packaging for the shipment. In the case of the GE-100 or GE-2000, use of the packages is arranged by rental agreement with the GE Vallecitos Nuclear Center in Pleasanton, California.

ORNL will be responsible for preparing and returning the empty package to GE in a timely manner after each shipment and for returning the empty handling container to INEEL after each shipment.

8.1 THE GE-100 CASK

The GE-100 cask (CoC 5926) is a steel-shelled, lead-shielded shipping cask approximately 20 in. in diameter and 27 in. tall; it weighs about 4,800 lb and has a central cavity 7 5/8 in. in diameter by 10 in. high. The package has 5 7/8 in. of lead shielding surrounding the cavity, and is designed to allow additional shielding in the cavity, if necessary. The cask is certified to transport irradiated fuel rods. The certification has a current expiration date of May 31, 2003.

8.2 THE GE-2000 CASK

The GE-2000 cask (CoC 9228) is a steel-shelled, lead shielded shipping cask, approximately 38.5 in. in diameter and 71.0 in. in height; it has a central cavity that is 26.5 in. in diameter and 54.0 in. deep; it is certified to transport irradiated fuel rods and fuel assemblies (including HFIR spent cores). Shielding consists of the two 1 in. steel shells and 4 in. of lead surrounding the cavity. The cask has a toroidal energy absorber attached to both its top and bottom. The gross weight of the package is 33,550 lb. The certification has a current expiration date of June 30, 1999.

9. SHIPMENT PREPARATION

In addition to observing the proper packaging procedures for the shipping container, INEEL is responsible for preparing the shipping papers, ensuring that the marking and labeling are correct, and supplying the proper placards to the carriers. The carrier is responsible for attaching the placards, as is required by DOT.

10. PROPOSED ROUTES

All shipments of irradiated test specimen capsules made from INEEL to ORNL in this campaign will be by highway. Two representative routes have been calculated for each shipment using the software program called HIGHWAY, which was developed by DOE specifically to select routes for shipments of radioactive materials using criteria set forth in U.S. DOT regulations. The two representative routes are briefly described below and in more detail in Attachment C. The two routes, designated Route A and Route B, have been identified as the most direct routes between INEEL and ORNL. Both routes may also be considered as "preferred" routes, as these meet the U.S. DOT regulations should the shipment quantity be sufficiently large to invoke a Highway Route Controlled Quantity (HRCQ) designation. INEEL, as the shipper, will be responsible for determining if the shipment quantity must be HRCQ-designated, and will, working with the carrier, select the actual route to be used for each shipment, in compliance with applicable

regulations. Should the shipment be less than a HRCQ, the actual route used will be a typical route used by the carrier for INEEL-to-ORNL shipments. The actual shipment route will be specified in the final arrangements among INEEL, the carrier, and ORNL.

10.1 INEEL TO ORNL

- A. The Route A is 27 miles longer than the Route B, but takes about one half hour less driving time, based on the legal highway speed limits along each route segment. Route A goes south on I-15 to Utah joining I-84, and then turns southeasterly and connects with I-80 to proceed east from Utah through Wyoming and Nebraska (with a deviation around Omaha) to I-29. It then follows I-29 south through southwestern Iowa and northwestern Missouri, circumventing the Kansas City area to access I-70 and follows it to St. Louis, Missouri. Circumventing the city of St. Louis, it proceeds southeastward to Mt. Vernon, Illinois, and then south via I-57 to I-24 at Pulleys Mill, Illinois. The route then follows I-24 through Paducah, Kentucky, to Nashville, Tennessee, and then proceeds eastward to Oak Ridge, Tennessee, by I-40 and State 95.
- B. The alternative route (Route B), although shorter than Route A, takes additional driving time due to slower driving times around Denver and lower speed limits in Kansas. Route B follows the same path from INEEL to Laramie, Wyoming, where it proceeds south on I-25 to Denver, Colorado. At Denver, it forks easterly onto I-76 and then I-270 before joining I-70 and proceeds through eastern Colorado and Kansas. Near Kansas City, Kansas, it follows I-435 around the southern part of the metropolitan area. Southeast of Kansas City, Missouri, it rejoins the preferred route and follows the same path to ORNL.

The actual shipment route will be specified in the final arrangements between INEEL and ORNL. The carrier will be provided the exact route by INEEL prior to the final shipment approval.

11. EMERGENCY PLANNING AND RESPONSE

State, tribal, and local government officials are responsible for emergency response to any accident within their jurisdictions. Initial responders administer first aid, isolate the area, attempt to identify the hazard, and notify appropriate state and federal authorities. Federal agencies respond to an emergency when specifically requested to do so by the state, tribal, or local government officials. DOE is the primary agency for providing radiological monitoring and assessment assistance. DOE's support ranges from giving technical advice by telephone to sending highly trained personnel and equipment to the accident site to help identify and minimize any radiological hazards. The carrier of the shipment is responsible for providing emergency response assistance and recovery and restoration actions, as necessary.

11.1 EMERGENCY PREPAREDNESS

As the DOE-designated shipper, INEEL will provide shipper-related emergency information and maintain a 24-h emergency telephone contact for technical advice and detailed information regarding the shipment. This telephone number is recorded on the shipping papers that accompany the shipment.

11.2 NOTIFICATIONS

11.2.1 Carrier Breakdown

The carrier driver will notify the dispatch center when mechanical problems have been encountered or if a driver is incapacitated. If assistance and replacement equipment or drivers are needed, the carrier dispatch center will notify the shipper. Information pertaining to the vehicle breakdown shall be noted in the carrier dispatch center's log. If the vehicle must deviate from the preferred route for vehicle repair or any other condition that makes continued use of the preferred route unsafe, the dispatch center will notify the shipper that the vehicle will be deviating from the preferred route. INEEL will notify ORNL of any delay resulting from driver or mechanical problems. The INEEL Packaging and Transportation Manager is M.D. Ruska, (208) 526-2414. The ORNL Traffic Manager is C. E. Eblen (423) 574-7014.

11.2.2 Severe Weather

Severe weather information can be obtained from numerous sources. Upon indication of severe weather, the carrier dispatch center shall notify the driver and obtain the driver's input (if not initially alerted to the weather conditions by the driver). The center will then obtain further information from the state police of the affected states, and either:

- divert the driver, truck, and cargo to a state-designated safe parking haven until weather improves;
- direct the driver to remain at the present location until weather conditions permit safe travel; or
- delay the shipment, if driver has not left the shipper's facility, until weather improves.

Details of the decisions of the carrier dispatch center will be entered into the dispatch center log.

11.2.3 Incident or Accident Enroute

In the event of an incident or accident, the driver will notify the 911 line, the appropriate state patrol, and the carrier dispatch center of the event. If the driver is unable to respond, the carrier dispatch center will notify the state patrol that the driver is not responding. The state patrol can then locate the truck and establish an incident command center, if necessary. Following the alert

of the local officials, the driver or the carrier dispatch center will contact the shipper's 24-h emergency notification number [phone (208) 526-1515].

Any state, tribal, local, or private sector organizations needing radiological assistance can call the nearest DOE RCO to obtain information, advice, or assistance. The DOE Regional Coordinator decides what action is needed based upon the request. Following initial contact, the DOE RCO also ensures that the appropriate state or tribal personnel are contacted in order to effect the appropriate involvement of state or tribal officials and resources. If the emergency is such that personnel or equipment are needed at the accident scene, the RCO coordinates the activation of a DOE Radiological Assistance Program (RAP) team. The RCO offices and phone numbers are listed in Attachment A.

11.3 EMERGENCY RESPONSE

The emergency-related roles and responsibilities that support this *Shipment Plan* are outlined below. As the DOE-designated shipper, INEEL will provide shipper-related emergency information and maintain a 24-hour emergency telephone contact [phone (208) 526-1515] for technical advice and detailed information regarding the shipments.

- The carrier driver, if able, will make the emergency notifications previously described and will undertake first-aid actions, control the initial accident scene, provide assistance to first responders, and perform other emergency actions as described in the carrier's emergency response plan.
- First responders (local law enforcement, fire fighters, and emergency medical service personnel) will be guided in their initial response actions by information contained in the *1996 North American Emergency Response Guidebook*. Guide 165 (Ref. 10) applies to the shipment of the irradiated capsules and is attached for reference (Attachment D). The *Guidebook* shall be in possession of the driver, and Guide 165 or other similar information must be attached to the shipping papers.
- The carrier will be given first opportunity to dispatch a crew to the affected area. The states maintain specialized state-level hazardous materials or radiological assistance teams (RATs) that may be activated to provide technical assistance and mitigation during emergencies. DOE will provide RATs from one of its regional offices to advise or assist in cleanup operations, if requested.
- All public contact and release of information will be coordinated through the local officials who have established an incident command. All information released will be with the concurrence of all parties involved with the transportation and local incident command.

11.4 RECOVERY

The carrier has primary responsibility for package and tractor-trailer recovery operations. Recovery will not begin until the emergency phase of any accident is terminated, following a decision that no further radiological or other hazard is present. DOE will assist the carrier in recovery operations, where appropriate. States can exercise their vehicle inspection responsibilities before permitting the recovered vehicle to proceed to its destination, the nearest DOE facility, or to return to the shipper.

11.5 CLEANUP AND SITE RESTORATION

The carrier has primary responsibility for cleanup and site restoration following an emergency. Standards for such actions will be as established by regulation and by authorities in the affected jurisdictions.

After the immediate threat of the accident has passed, the lead federal radiological monitoring and assessment role is transferred from DOE to the U.S. Environmental Protection Agency (EPA). Although DOE would recover the irradiated test fuel (should that be necessary), it is the responsibility of the shipper to repackage and dispose of, as appropriate, any primary radioactive material spilled, plus any contaminated material.

12. PHYSICAL PROTECTION

The shipper, INEEL, acting on behalf of DOE, is required by DOE to meet the NRC physical protection requirements. Based on the quantities of materials involved in each planned shipment, some of the shipments (particularly the 3rd shipment of either the APT or HPT) may meet the quantity limits for "special nuclear material, of low strategic-significance" when offering the material to a carrier. The defining limit for materials of "low strategic significance" is special nuclear material containing more than 15 g of plutonium, but less than 500 g. DOE is exempt from the NRC requirements when using a DOE transport system [10 CFR Part 73.6 (d)]; however, since a commercial carrier will be involved, and the DOE requirements for physical protection of nuclear materials in transit are found in the NRC regulations [per DOE Orders 460.1A (Ref. 11) and 460.2 (Ref. 12)]. The planned shipments of the irradiated MOX capsules meet the requirements for low strategic-significance material.

The in-transit regulations for low strategic-significance material are found in 10 CFR Part 73.67 (g)(4). The regulations require a response plan or procedures to deal with either threat or theft. INEEL shall comply accordingly.

13. INSURANCE AND LIABILITY ISSUES

The carrier will maintain necessary insurance and liability coverage for the shipments. The shipper will verify the carrier's insurance and liability coverage.

14. REFERENCES

1. B.S. Cowell and S.A. Hodge, *Fissile Materials Disposition Program Light Water Reactor Mixed Oxide Fuel Irradiation Test Project Plan, Revision 1*, ORNL/MD/LTR-78, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 1998 (revision to July 1997 plan).
2. B. S. Cowell, *ATR Capsule Assembly Loading and Operation Schedule*, ORNL/MD/LTR-91, Revision 1, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, February 1998 (revision to September 1997 plan).
3. L. S. Dickerson and M. J. Welch, *Fresh Test Fuel Shipment Plan for the LWR MOX Fuel Irradiation Test Project*, ORNL/MD/LTR-87, Rev. 0, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, September 12, 1997.
4. B.S. Cowell and S.A. Hodge, *Fissile Materials Disposition Program Light Water Reactor Mixed Oxide Fuel Irradiation High Power Test Project Plan*, ORNL/MD/LTR-125, Revision 1, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1998 (revision to April 1998 plan).
5. B. S. Cowell, *ATR Capsule Assembly Loading and Operation Schedule for the High-Power Mixed-Oxide Irradiation Test*, ORNL/MD/LTR-132, Revision 1, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, July 1998 (revision to June 1998 plan).
6. U.S. Department of Energy, "Motor Carrier Evaluation Program (MCEP)," from the Environmental Management Home Page, <http://www.em.doe.gov/trans/mcep.html>, Sept. 15, 1995.
7. Federal Highway Administration, U.S. Department of Transportation, *Federal Motor Carrier Safety Regulations*, Chapter III, Subpart B, Appendix G, *Minimum Periodic Inspection Standards*.
8. Commercial Vehicle Safety Alliance, "North American Uniform Out-of-Service Criteria," Appendix A, Parts I, II, and III, April 1, 1995.
9. B. S. Cowell, *Technical Specifications: Mixed-Oxide Pellets for the Light-Water Reactor Irradiation Demonstration Test*, ORNL/MD/LTR-75, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, Tennessee, June 1997.
10. Research and Special Programs Administration, U. S. Department of Transportation, *1996 North American Emergency Response Guidebook*, Washington, D.C., 1996.
11. U.S. Department of Energy, "Packaging and Transportation Safety," DOE Order 460.1A, Washington, D.C., Oct. 2, 1996.
12. U. S. Department of Energy, "Departmental Material Transportation and Packaging Management," DOE Order 460.2, Change 1, Washington, D.C., October 26, 1996.

ATTACHMENT A

TELEPHONE NUMBERS OF DOE REGIONAL COORDINATING OFFICES

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TELEPHONE NUMBERS OF DOE REGIONAL COORDINATING OFFICES

1. Region 1: Brookhaven
516-282-2200
2. **Region 2: Oak Ridge**
423-576-1005
3. Region 3: Savannah River
803-725-3333
4. Region 4: Albuquerque
505-845-4667
5. Region 5: Chicago
708-252-4000
6. **Region 6: Idaho**
208-526-1515
7. Region 7: Oakland
510-637-1821
8. Region 8: Richland
509-373-3800

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ATTACHMENT B
MATERIAL ISOTOPIC ANALYSIS

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MATERIAL ISOTOPIC ANALYSIS

The LWR MOX fuel irradiation tests involve the irradiation of MOX fuel test specimen capsules in the ATR at INEEL. In the first test (known as the Average Power Test), 11 capsules will undergo burnups from 8 to 30 GWd/MT. Beginning in early 1999, a second test (known as the High Power Test) will subject a total of 13 capsules to burnups ranging from 15 to 45 GWd/MT.

Unlike the fresh MOX fuel capsules, the irradiated capsules will need to be shipped in a shielded cask to reduce the external package dose rate to safe levels during handling and transport. Using the ORIGEN-S code, the characteristics of the discharged MOX fuel test specimen capsules were evaluated as a function of burnup and decay time after reactor shutdown. This information provides a foundation for (a) identifying the radiation source terms for the capsules as a function of time after discharge, (b) determining the proper shielding required to protect workers during handling operations, and (c) evaluating the various packagings that may be used to transport the capsules from INEEL to ORNL.

Table B.1 presents information on the approximate curie levels expected in each irradiated capsule as a function of burnup and time after shutdown of the reactor. The individual isotopes are consolidated into three major groups of light elements, actinides, and fission products. Note that for a given cooling time, activity levels from the light elements and actinides increase almost in direct proportion to the burnup. The activity levels from fission products, however, vary only a little with burnup, and in fact, decrease slightly at the higher burnup level. This is primarily due to the fact that in order to achieve the higher burnups (e.g., 20 and 30 GWd/MT) the capsules are irradiated through a number of reactor operating cycles, between which the reactor is shut down to, for example, remove experiments. Many of the shorter-lived fission products generated in early irradiation cycles have decayed by the time the higher burnups are reached.

As the burnup increases, the fissionable isotopes (^{235}U , ^{239}Pu , and ^{241}Pu) decrease. This is shown in Table B.2. After a burnup of 8 GWd/MT has been achieved, there remains a total of about 3.12 grams of fissile material in each capsule. After 20 and 30 GWd/MT, the total fissile material in each capsule has decreased to approximately 1.77 and 1.09 grams, respectively. The fissionable plutonium isotopes follow this same pattern, decreasing from 2.95 grams after a burnup of 8 GWd/MT to 1.03 grams after 30 GWd/MT.

Note: Table B.1 and B.2 provide estimates of the radioactivity and composition of the irradiated MOX fuel test specimen capsules for the Average-Power Test. As part of preparing each shipment for transport, INEEL will be responsible for providing more precise and detailed information about the isotopic composition of each shipment on the official shipping papers and as part of any safety analysis that may be required by INEEL or DOE procedures.

Table B.1 Irradiated Fuel Capsule Activity – Average Power Test

Average Burnup GWd/MT		Curies		
		30 days decay	60 days decay	90 days decay
8	Light elements	1.07E+01	1.09E+01	6.95E+00
	Actinides	7.17E+00	6.71E+00	6.43E+00
	Fission products	9.53E+02	6.11E+02	4.37E+02
	Total	9.71E+02	6.29E+02	4.50E+02
20	Light elements	2.97E+01	1.97E+01	1.47E+01
	Actinides	1.37E+01	1.34E+01	1.33E+01
	Fission products	9.45E+02	6.59E+02	5.08E+02
	Total	9.89E+02	6.92E+02	5.36E+02
30	Light elements	4.00E+01	2.86E+01	2.29E+01
	Actinides	2.12E+01	2.06E+01	2.02E+01
	Fission products	7.89E+02	5.74E+02	4.59E+02
	Total	8.50E+02	6.23E+02	5.02E+02

Note: "Light elements" are also known as "activation products". Calculated composition based on one MOX capsule.

Table B.2 Irradiated Fuel Capsule Actinide Composition – Average Power Test

Isotope	Amount in one fuel capsule (g)		
	8 GWd/MT	20 GWd/MT	30 GWd/MT
²³⁵ U	1.70E-01	8.63E-02	5.80E-02
²³⁶ U	4.87E-03	8.40E-03	1.27E-02
²³⁸ U	7.18E+01	7.09E+01	7.07E+01
²³⁹ Pu	2.91E+00	1.56E+00	8.65E-01
²⁴⁰ Pu	4.67E-01	7.14E-01	7.93E-01
²⁴¹ Pu	4.04E-02	1.19E-01	1.70E-01
²⁴² Pu	3.02E-03	2.32E-02	5.75E-02

Note: Calculated composition based on one MOX capsule.

ATTACHMENT C

**ROUTING ANALYSIS FOR LWR MOX IRRADIATED FUEL IRRADIATION TEST—
INEEL TO ORNL**

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ROUTING ANALYSIS FOR LWR MOX IRRADIATED FUEL IRRADIATION TEST— INEEL to ORNL

C.1 PURPOSE OF THE SHIPMENTS

The purpose of the planned shipments is to transport irradiated MOX fuel test specimen capsules from INEEL to ORNL so that the capsules may undergo PIE. A total of two shipping campaigns are planned, with a maximum of three shipments per campaign. The first shipping campaign involves capsules irradiated during the Average Power Test, which commenced irradiation in February 1998. Under this campaign, the first shipment will include two irradiated capsules and should commence shortly after these two capsules have been discharged from the ATR reactor (scheduled for September 1998). Two other shipments (of two capsules and seven capsules) will follow at intervals of approximately 12 months after the first shipment. A second shipping campaign, for capsules irradiated under the High Power Test, is planned. As before, a total of three shipments would occur at approximately 12 month intervals. It may be possible to ship APT and HPT irradiated capsules in a single shipment, thus reducing both the number of shipments and project costs.

Two routes have been calculated using the software program called HIGHWAY, which has been developed by DOE specifically to select routes for shipments of radioactive materials using criteria set forth in DOT regulations. Two possible routes are detailed below. Both routes may be considered as preferred routes. However, the actual shipment route will be specified in the final arrangements among INEEL, the carrier, and ORNL.

C.2 SHIPMENT DESCRIPTION

The shipment will be conducted using a commercial carrier and will use a certified packaging in which the irradiated capsules will be placed. Each irradiated capsule is composed of a stainless steel tube and end caps that are seal-welded to encapsulate a sealed, zircaloy clad MOX fuel pin. Some shipments may have as few as a single irradiated capsules while other shipments could have as many as 8 capsules.

C.3 ROUTING ANALYSIS

A preliminary isotopic analysis of APT irradiated capsules is given in Appendix B. Clearly, each irradiated capsule will contain sufficient activity to require the use of a Type B package. A Type B package is required when the radioactive contents exceed either the A_1 or A_2 limits set forth in the DOT regulations. Any shipment of radioactive material within a single package that exceeds 3000 times either the A_1 or A_2 value is by definition a highway route controlled quantity (HRCQ) shipment. Additionally, when isotopic mixtures are involved, all isotopes must be evaluated relative to their unique A_1 or A_2 values to determine if the mixture exceeds a HRCQ. HRCQ shipments must follow the regulations for the routing for radioactive materials, which are found in 49 CFR Part 397.101. INEEL will need to determine if any of the planned shipments will be

designated as HRCQ and take the necessary steps to ensure that these shipments comply with the additional labels and placarding requirements.

Using the HIGHWAY code, two possible routes were selected. Because of the uncertainty about the actual radioactive composition of each shipment, the HM-164/state-preferred routing criteria were employed. Thus, the routes evaluated are HRCQ routes. Basically, the routing criteria dictate that (1) the shipment maximizes use the U.S. Interstate Highway system, (2) the shipment uses the shortest distance route from the origin to the Interstate and from the Interstate to the destination, (3) shipment time is minimized, (4) the shipment uses state-designated "preferred" routes and Interstate bypasses around cities.

- A. The preferred route (Route A) is 27 miles longer than the Route B, but takes about one half hour less driving. Route A goes south on I-15 to Utah joining I-84, and then turns southeasterly and connects with I-80 to proceed east from Utah through Wyoming and Nebraska (with a deviation around Omaha) to I-29. It then follows I-29 south through southwestern Iowa and northwestern Missouri, circumventing the Kansas City area to access I-70 and follows it to St. Louis, Missouri. Circumventing the city of St. Louis, it proceeds southeastward to Mt. Vernon, Illinois, and then south via I-57 to I-24 at Pulleys Mill, Illinois. The route then follows I-24 through Paducah, Kentucky, to Nashville, Tennessee, and then proceeds eastward to Oak Ridge, Tennessee, by I-40 and State 95.
- B. The alternative preferred route, although shorter than Route A, takes additional driving time due to slower driving times around Denver and lower speed limits in Kansas. Route B follows the same path from INEEL to Laramie, Wyoming, where it proceeds south on I-25 to Denver, Colorado. At Denver, it forks easterly onto I-76 and then I-270 before joining I-70 and proceeds through eastern Colorado and Kansas. Near Kansas City, Kansas, it follows I-435 around the southern part of the metropolitan area. Southeast of Kansas City, Missouri, it rejoins the preferred route and follows the same path to ORNL.

Table C.1 provides a brief summary of potential transportation routes between INEEL and ORNL. Figure C.1 provides a map of the two representative routes.

Tables C.2 through C.3 contain the detailed HIGHWAY output for each of the two representative routes between INEEL and ORNL. Each HIGHWAY output has three general segments of information. The first provides a brief description and summary of the route, including summaries of the route by type of road. The second segment of the HIGHWAY output (Routing through) provides a detailed listing of the calculated route. Finally, the third segment provides a detailed listing of the population density and a summary that provides input to RADTRAN, DOE's tool for calculating transportation risk assessment.

Table C.1 Summary—Selected transportation routes between INEEL

Route identification	Distance (miles)	Time (h)	Population density (population/mile ²)		
			Rural	Suburban	Urban
Route A, preferred route	2079	33:58	16.5	846.6	5705.1
Route B, alternative preferred	2052	34:27	16.5	865.6	5588.6

Figure C.1 Map of representative routes between INEEL and ORNL.

Table C.2 Route A between INEEL and ORNL

From: INEEL Leaving : 7/08/98 at 13:06 MDT Arriving: 7/10/98 at 1:02 EDT
 To: ORNL Total Road Time: 33:58 Total Miles: 2079.0

Route Type: Q with 2 Driver(s) Time Bias: 1.00 Mile Bias: .00 Toll Bias: 1.00

Base route for alternative routing

The following constraints are in effect:

- Route avoids links prohibiting truck use
- Route follows HM-164/State preferred routes of high level radioactive waste
- Route avoids ferry crossings
- Route avoids access roads between nonintersecting Interstate Highways

Weighting used with preferred highways: 10.0

Mileage by Highway Sign Type:

Interstate: 2033.0 U.S.: 40.0 State: 3.0 Turnpike: .0
 County: .0 Local: 3.0 Other: .0

Mileage by Highway Lane Type:

Limited Access Multilane: 2033.0 Limited Access Single Lane: .0
 Multilane Divided: .0 Multilane Undivided: .0
 Principal Highways: 40.0 Through Highways: .0 Other: 6.0

State Mileage

TN	209.0
KY	95.0
IL	178.0
MO	375.0
IA	100.0
NE	459.0
WY	402.0
UT	128.0
ID	133.0

Routing through:

.0		INEEL		ID	.0	0:00	7/08/98 at 13:06
1.0	LOCAL	ID NATL ENG LAB	U20	LOCL ID	1.0	0:02	7/08/98 at 13:08
4.0	U20	ATOMIC CITY	NW U20	U26 ID	5.0	0:07	7/08/98 at 13:13
36.0	U26	BLACKFOOT	NW I15	X92 ID	41.0	0:50	7/08/98 at 13:56
112.0	I15	TREMONTON	W I15	I84 UT	153.0	2:20	7/08/98 at 15:25
39.0	I15	OGDEN	S I15	I84 UT	192.0	2:56	7/08/98 at 16:01
39.0	I84	ECHO	I80	I84 UT	231.0	3:27	7/08/98 at 16:32
877.0	I80	OMAHA	SW I680	I80 NE	1108.0	16:40	7/09/98 at 6:46
17.0	I680	CRESCENT	W I29	I680 IA	1125.0	16:59	7/09/98 at 7:04
10.0	I29	LOVELAND	SW I29	I680 IA	1135.0	17:08	7/09/98 at 7:13
16.0	I680	MINDEN	NW I680	I80 IA	1151.0	17:23	7/09/98 at 7:28
23.0	I80	COUNCIL BLUFFS	SE I29	I80 IA	1174.0	18:14	7/09/98 at 8:19
157.0	I29	KANSAS CITY	NW I29	I435 MO	1331.0	20:33	7/09/98 at 10:38
28.0	I435	KANSAS CITY	SE I435	I70 MO	1359.0	20:57	7/09/98 at 11:02
224.0	I70	ST LOUIS	NW I270	I70 MO	1583.0	24:41	7/09/98 at 14:46
22.0	I270	EDWARDSVILLE	SW I255	I270 IL	1605.0	25:04	7/09/98 at 15:09
11.0	I255	WASHINGTON PK	SE I255	I64 IL	1616.0	25:16	7/09/98 at 15:21
67.0	I64	MT VERNON	NW I57	I64 IL	1683.0	26:29	7/09/98 at 16:34
5.0	I57	MT VERNON	SW I57	I64 IL	1688.0	27:04	7/09/98 at 17:09
48.0	I57	PULLEYS MILL	W I24	I57 IL	1736.0	27:57	7/09/98 at 18:01
179.0	I24	INGLEWOOD	W I24	I65 TN	1915.0	30:49	7/09/98 at 20:54
5.0	I24	NASHVILLE	SE I24	I40 TN	1920.0	30:55	7/09/98 at 20:59
2.0	I24	NASHVILLE	E I24	I40 TN	1922.0	30:57	7/09/98 at 21:02
152.0	I40	LENOIR CITY	NW I40	X364 TN	2074.0	33:49	7/10/98 at 0:54
3.0	S95	X-10	W S95	LOCL TN	2077.0	33:55	7/10/98 at 1:00
2.0	LOCAL	ORNL		TN	2079.0	33:58	7/10/98 at 1:02

Table C.2 Route A between INEEL and ORNL (continued)

Population Density from: INEEL
To ORNL

		MILEAGE WITHIN DENSITY LEVELS											
St	Miles	0	<0.0 -5.0	5.0 -22.7	22.7 -59.7	59.7 -139	139 -326	326 -821	821 -1861	1861 -3326	3326 -5815	5815 -9996	>9996
TN	209.0	23.0	22.7	44.4	46.5	32.3	22.3	6.8	6.6	1.7	2.0	.7	.0
KY	95.0	3.7	4.6	36.4	25.0	10.3	9.1	2.4	2.2	1.2	.0	.0	.0
IL	178.0	27.4	44.1	34.2	31.6	14.1	10.9	7.8	4.6	1.7	1.0	.5	.0
MO	375.0	28.5	84.6	113.3	40.7	24.6	17.3	20.5	23.4	10.7	7.6	2.7	1.0
IA	100.0	4.8	28.0	39.7	11.2	7.7	5.1	1.8	1.3	.2	.2	.0	.0
NE	459.0	48.8	207.1	130.0	31.5	12.0	10.9	6.5	2.9	5.1	3.1	1.1	.0
WY	402.0	78.8	253.4	30.8	12.5	4.6	6.7	6.1	4.7	3.1	.5	.7	.0
UT	128.0	19.0	50.5	22.0	8.2	14.6	5.4	2.5	2.2	2.2	.9	.5	.0
ID	133.0	13.9	54.1	36.6	13.0	5.5	4.7	1.9	1.3	1.5	.6	.0	.0
Route Total													
	2079.0	247.9	749.1	487.5	220.3	125.6	92.5	56.4	49.2	27.4	15.9	6.2	1.0
Percentages													
		11.9	36.0	23.4	10.6	6.0	4.4	2.7	2.4	1.3	.8	.3	.0
Basis: 1990 Census													

Basis: 1990 Census

RADTRAN Input Data		Rural	Suburban	Urban
Weighted Population				
People/sq. mi.		16.5	846.6	5705.1
People/sq. km.		6.4	326.9	2202.7
Distance				Total
Miles		1830.4	225.5	23.1
Kilometers		2945.6	362.9	37.1
Percentage		88.0	10.8	1.1
Basis (people/sq. mi.)		<139	139-3326	>3326 1990 Census

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

Table C.3 Route B between INEEL and ORNL

From: INEEL ID Leaving : 7/8/98 at 13:06 MDT
to : ORNL TN Arriving: 7/10/98 at 1:31 EDT

Route Type: Q with 2 Driver(s) Total Road Time: 34:27
Time Bias: 1.00 Mile Bias: .00 Toll Bias: 1.00 Total Miles: 2052.0

Weighting factor used for alternative routing: .100

The following constraints are in effect:

Route avoids links prohibiting truck use
Route follows HM-164/State preferred routes of high level radioactive waste
Route avoids ferry crossings
Route avoids access roads between nonintersecting Interstate Highways

Weighting used with preferred highways: 10.0

Mileage by Highway Sign Type:

Interstate: 2006.0 U.S.: 40.0 State: 3.0 Turnpike: .0
County: .0 Local: 3.0 Other: .0

Mileage by Highway Lane Type:

Limited Access Multilane: 2006.0 Limited Access Single Lane: .0
Multilane Divided: .0 Multilane Undivided: .0
Principal Highways: 40.0 Through Highways: .0 Other: 6.0

State Mileage

TN	209.0
KY	95.0
IL	178.0
MO	250.0
KS	432.0
CO	260.0
WY	367.0
UT	128.0
ID	133.0

Routing through:

.0		INEEL		ID	.0	0:00	7/08/98 at 13:06
1.0	LOCAL	ID NATL ENG LAB	U20	LOCL ID	1.0	0:02	7/08/98 at 13:08
4.0	U20	ATOMIC CITY	NW U20	U26 ID	5.0	0:07	7/08/98 at 13:13
36.0	U26	BLACKFOOT	NW I15	X92 ID	41.0	0:50	7/08/98 at 13:56
112.0	I15	TREMONTON	W I15	I84 UT	153.0	2:20	7/08/98 at 15:25
39.0	I15	OGDEN	S I15	I84 UT	192.0	2:56	7/08/98 at 16:01
39.0	I84	ECHO	I80	I84 UT	231.0	3:27	7/08/98 at 16:32
389.0	I80	CHEYENNE	SW I25	I80 WY	620.0	9:38	7/08/98 at 22:43
91.0	I25	COMMERCE CITY	W I25	I76 CO	711.0	11:05	7/09/98 at 0:11
1.0	I76	COMMERCE CITY	NW I270	I76 CO	712.0	11:06	7/09/98 at 0:12
5.0	I270	DENVER	NE I270	I70 CO	717.0	11:12	7/09/98 at 0:17
526.0	I70	TOPEKA	W I470	I70 KS	1243.0	20:00	7/09/98 at 10:05
7.0	I470	TOPEKA	S I335	I470 KS	1250.0	20:08	7/09/98 at 10:12
5.0	I470\$ TKST\$	TOPEKA	E I470	I70 KS	1255.0	20:13	7/09/98 at 10:18
42.0	I70 \$ TKST\$	BONNER SPRINGS	N I70	X224 KS	1297.0	20:49	7/09/98 at 10:54
4.0	I70	KANSAS CITY	W I435	I70 KS	1301.0	20:53	7/09/98 at 10:58
31.0	I435	KANSAS CITY	SE I435	I70 MO	1332.0	21:26	7/09/98 at 11:31
224.0	I70	ST LOUIS	NW I270	I70 MO	1556.0	25:10	7/09/98 at 15:14
22.0	I270	EDWARDSVILLE	SW I255	I270 IL	1578.0	25:33	7/09/98 at 15:37
11.0	I255	WASHINGTON PK	SE I255	I64 IL	1589.0	25:45	7/09/98 at 15:49
67.0	I64	MT VERNON	NW I57	I64 IL	1656.0	27:28	7/09/98 at 17:32
5.0	I57	MT VERNON	SW I57	I64 IL	1661.0	27:33	7/09/98 at 17:38
48.0	I57	PULLEYS MILL	W I24	I57 IL	1709.0	28:26	7/09/98 at 18:30
179.0	I24	INGLEWOOD	W I24	I65 TN	1888.0	31:48	7/09/98 at 21:53
5.0	I24	NASHVILLE	SE I24	I40 TN	1893.0	31:54	7/09/98 at 21:58
2.0	I24	NASHVILLE	E I24	I40 TN	1895.0	31:56	7/09/98 at 22:01
152.0	I40	LENOIR CITY	NW I40	X364 TN	2047.0	34:18	7/10/98 at 1:22
3.0	S95	X-10	W S95	LOCL TN	2050.0	34:24	7/10/98 at 1:28
2.0	LOCAL	ORNL		TN	2052.0	34:27	7/10/98 at 1:31

Table C.3 Route B between INEEL and ORNL (continued)

Population Density from: INEEL
to : ORNL

ID
TN

		----- Mileage within Density Levels -----											
St	Miles	0	<0.0	5.0	22.7	59.7	139	326	821	1861	3326	5815	
			-5.0	-22.7	-59.7	-139	-326	-821	-1861	-3326	-5815	-9996	>9996
TN	209.0	23.0	22.7	44.4	46.5	32.3	22.3	6.8	6.6	1.7	2.0	.7	.0
KY	95.0	3.7	4.6	36.4	25.0	10.3	9.1	2.4	2.2	1.2	.0	.0	.0
IL	178.0	27.4	44.1	34.2	31.6	14.1	10.9	7.8	4.6	1.7	1.0	.5	.0
MO	250.0	20.5	43.0	74.5	22.1	15.2	10.4	17.6	22.4	12.7	7.5	3.0	1.0
KS	432.0	25.3	206.9	93.7	43.8	18.7	15.3	9.3	8.9	3.9	4.9	.8	.2
CO	260.0	34.3	134.6	33.3	17.9	14.3	12.0	4.5	4.3	1.9	2.4	.3	.0
WY	367.0	69.3	239.7	23.2	12.3	4.2	5.3	5.6	4.3	2.5	.1	.5	.0
UT	128.0	19.0	50.5	22.0	8.2	14.6	5.4	2.5	2.2	2.2	.9	.5	.0
ID	133.0	13.9	54.1	36.6	13.0	5.5	4.7	1.9	1.3	1.5	.6	.0	.0
Route													
Total	2052.0	236.4	800.2	398.4	220.3	129.3	95.5	58.5	56.8	29.2	19.4	6.4	1.1
Percentages													
		11.5	39.0	19.4	10.7	6.3	4.7	2.9	2.8	1.4	.9	.3	.1
Basis: 1990 Census													

RADTRAN Input Data

Rural Suburban Urban

Weighted Population

People/sq. mi.	16.5	865.6	5588.6
People/sq. km.	6.4	334.2	2157.8

Distance

Miles	1784.6	240.1	26.9	Total
Kilometers	2871.9	386.4	43.3	3302.3
Percentage	87.0	11.7	1.3	

Basis (people/sq. mi.) <139 139-3326 >3326 1990 Census

Note: Due to rounding, the sum of the mileages in the individual population categories may not equal the total mileage shown on this report.

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ATTACHMENT D

**GUIDE 165, RADIOACTIVE MATERIALS (FISSILE—LOW TO HIGH LEVEL
RADIATION) FROM THE *1996 NORTH AMERICAN EMERGENCY RESPONSE
GUIDE***

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POTENTIAL HAZARDS

HEALTH

- Radiation presents minimal risk to transport workers, emergency response personnel, and the public during transportation accidents. Packaging durability is related to potential hazards of material.
- Undamaged packages are safe; contents of damaged packages may cause external and/or internal radiation exposure.
- Packages (drums or boxes) identified as "Type AF" or "IF" by marking on packages or by shipping papers contain materials that are not life endangering if released. External radiation levels are low and packages are designed, evaluated, and tested to control releases and to prevent a fission chain reaction under severe transport accident conditions.
- Packages (metal and usually very heavy) identified as "Type B(U)F" or "B(M)F" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, fission chain reactions are prevented and releases are not expected to be life endangering for all accidents except those of utmost severity.
- The transport index (TI) shown on labels or a shipping paper might not indicate the radiation level at one meter from the package; instead, it may indicate controls needed during transport because of the fissile properties of the materials.
- Some radioactive materials cannot be detected by commonly available instruments.
- Water from cargo fire control is not expected to cause pollution.

FIRE OR EXPLOSION

- These materials are not flammable and packagings are designed to withstand fires without damage to contents.
- Radioactivity does not change flammability or other properties of materials.
- Type AF, Type IF, and Type B packages are designed and evaluated to withstand total engulfment in flames at temperatures of 800°C (1475°F) for a period of 30 minutes.

PUBLIC SAFETY

- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.**
- **Priorities for rescue, life-saving, first aid, and control of fire and other hazards are higher than the priority for measuring radiation levels.**
- Radiation Authority must be notified of accident conditions, and is usually responsible for radiological decisions.
- Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. • Stay upwind. • Keep unauthorized personnel away.
- Detain or isolate uninjured persons or equipment suspected to be contaminated; delay decontamination and cleanup until instructions are received from Radiation Authority.

PROTECTIVE CLOTHING

- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

EVACUATION

Large Spill

- Consider initial downwind evacuation for at least 100 meters (330 feet).

Fire

- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

EMERGENCY RESPONSE

FIRE

- Presence of radioactive material will not change effectiveness of fire control techniques.
- Move containers from fire area if you can do it without risk.
- Do not move damaged packages; move undamaged packages out of fire zone.

Small Fires

- Dry chemical, CO₂, water spray or regular foam.

Large Fires

- Water spray, fog (flooding amounts).

SPILL OR LEAK

- Do not touch damaged packages or spilled material.
- Slightly damaged or damp outer surfaces seldom indicate failure of packaging since most have an inner container.

Liquid Spills

- Package contents are seldom liquid. If any radioactive contamination resulting from a liquid release is present, it probably will be low-level.

FIRST AID

- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Apply artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Injured persons who contacted released material may be a minor contamination problem to contacted persons, equipment and facilities.
- Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

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