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Historical Summary of the Three Mile Island Unit 2 Core Debris Transportation Campaign

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U.S. Department of Energy Idaho Field Office

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a. Wastren, Inc., Germantown, Maryland 20874

ABSTRACT

Transport of the damaged core materials from the Unit 2 reactor of the Three Mile Island Nuclear Power Station (TMI-2) to the Idaho National Engineering Laboratory (INEL) for examination and storage presented many technical and institutional challenges, including assessing the ability to transport the damaged core; removing and packaging core debris in ways suitable for transport; developing a transport package that could both meet Federal regulations and interface with the facilities at TMI-2 and the INEL; and developing a transport plan, support logistics, and public communications channels suited to the task. This report is a historical summary of how the U.S. Department of Energy addressed those challenges and transported, received, and stored the TMI-2 core debris at the INEL. Subjects discussed include preparations for transport, loading at TMI-2, institutional issues, transport operations, receipt and storage at the INEL, governmental inquiries/investigations, and lessons learned. Because of public attention focused on the TMI-2 Core Debris Transport Program, the exchange of information between the program and public was extensive. This exchange is a focus for parts of this report to explain why various operations were conducted as they were and why certain technical approaches were employed. And, because of that exchange, the program may have contributed to a better public understanding of such actions and may contribute to planning and execution of similar future actions.

FOREWORD

In preparing this document, *Historical Summary of the Three Mile Island Unit 2 Core Debris Transportation Campaign*, the authors had two overriding objectives. The first was to provide a general reader, having no special technical background, an understandable and accurate account of the multiple-year effort to prepare, transport, receive, and store the Three Mile Island Unit 2 (TMI-2) core debris. As a minimum, we fully intend for the general reader to see these activities from the perspective of the individuals directly involved and responsible. The second objective was to provide sufficient information to be of value to a technical audience faced with a similar effort in the years ahead.

An uncontestable observation is that some in the public domain are opposed to transport (shipments) of nuclear waste, and opposition clearly makes such actions newsworthy. At the same time, the history of radioactive materials transport has an essentially impeccable safety record. There are no instances of health effects to transport workers or the general public from the radioactive nature of these transport operations. The TMI-2 transport campaign was planned and executed with attention to public safety as a very substantial and focused consideration, at least as focused as any previous nuclear materials transport action. It is now but a matter of history that public reaction to the TMI-2 transport campaign was substantial and required considerable efforts to address. In light of the need for engineers to support public communication efforts, we hope that frustrations we experienced during the campaign are not overly evident in the text.

It seems clear that transport of nuclear waste to retrievable storage and disposal facilities must go forward in the years ahead. There are simply no foreseeable acceptable alternatives for the ultimate disposal of nuclear waste other than those requiring such transportation actions. Should this report prove enlightening to some readers regarding how such actions have been, and can be, conducted safely, then we will have performed a service of possible future value.

ACKNOWLEDGEMENTS

We wish to acknowledge all those who played significant roles in the TMI-2 core debris transport campaign, including not only those who developed and implemented the campaign but also those who investigated, inquired into, or opposed the effort. The TMI-2 transport campaign was precedent-setting in the quantity of information that was transferred between the Department of Energy (DOE) and the public on the particulars of the TMI-2 transport activity and transport of radioactive waste in general. On the one side, the willingness of DOE and personnel of the shipping team to address each and every inquiry and concern as thoroughly and quickly as reasonably achievable, regardless of required effort and expenditures, was noteworthy; on the other side, the willingness of recipients of information to review, evaluate, and reach reasonable conclusions was much appreciated.

In particular, we acknowledge various DOE personnel, including the Secretaries of Energy, Undersecretaries, and related personnel for their efforts in responding to public concerns that arose from this activity; the Office of Nuclear Energy, especially David McGoff, Ted McIntosh, and Norman Klug, who were principals in providing DOE Headquarters' direction to the TMI-2 core debris shipping campaign preparations and implementation; the Office of Defense Programs, especially Larry Harmon, Paul Grimm, Roy Garrison, and their management, who labored extensively in assisting with the program's responses to the innumerable public inquiries; the Office of Environment, Safety, and Health, particularly Mary Walker who provided guidelines for complying with environmental protection regulations; Idaho Field Office personnel, including Troy Wade, Phil Hamric, Don Ofte, Willis Young (deceased), and Neil Burrell, who so aptly provided direction for implementing DOE's requirements in the TMI-2 transport effort; and the DOE TMI-2 Technical Integration Office Manager, Willis Bixby, whose wisdom and day-to-day management was so important to ultimate campaign success.

The members of the "team" who contributed to management and performance of the transport campaign are generally too numerous to mention with completeness. Certainly, GPU Nuclear's integrated team, consisting of its TMI-2 staff and two major contractors, Bechtel and Babcock & Wilcox (B&W), was outstanding in all areas of management, engineering, and operations; and is commended for efforts to ensure that "no stones were left unturned" in making the core debris shipments successful. Acknowledgements for contributions go to Frank Standerfer in TMI-2 Recovery Program Management; Dave Buchanan in site engineering management; Bob Barkanic in project engineering of the modifications to, and equipment installation at, the TMI-2 site; Frank Telenko and Bernie Smith in canister preparations and cask loading; Bill Conaway and Ray Hahn in cask receipt and preshipment operations; Bill Engle and John V. Smith in design engineering; and Paul Childress in canister design and testing. The members of this group and their co-workers put forth exceptional efforts for the program as needed, and when needed, with exemplary results. This group interfaced between canisters and cask, and cask and TMI-2 facility to make the shipments possible.

Deserved credit goes to the cask contractor Nuclear Packaging, a Pacific Nuclear Company, and their NuPac 125-B team, especially Richard Haelsig, Duanne Schmoker, Wayne Henkel, Robert Johnson, Steve Porter, and Dan Swannack, who were extraordinary in recognizing technical constraints while proposing workable solutions, and who were diligent in their efforts to ensure that the cask for the TMI-2 core debris, and the auxiliary handling equipment for the cask, were correct and timely.

The leadership provided at the Three Mile Island (TMI) site by EG&G Idaho's TMI Technical Integration Office (TIO) managers, Harold Burton, during most of the preparations to ship, and Phil Grant, during actual shipping operations, was crucial to success. The performance of EG&G Idaho employees Larry Ball in engineering and operations, Al Anselmo and Max Ruska in traffic management, Terry Smith in public/community relations, Ron Ayers in receipt and storage preparations and operations, Bill Crownover in contracts administration, Bill Franz and Steve Metzger in the TIO interface with GPU Nuclear, and Harley Reno in document support were invaluable. Thanks go to a cadre of workers of all disciplines who labored at the INEL to receive the shipments and store the TMI-2 core debris. Prominent among this cadre were equipment operators, safety personnel, drivers, Hot Shop personnel, health physics technicians, and security personnel.

The broad array of activities composing the TMI-2 core debris transport campaign involved too many special contributors to identify except in passing. Support activities were provided by Marilyn Warrant and Brian Josephs at Sandia National Laboratories in cask scale-model testing; Don Box and Scott Aaron in canister drop testing at Oak Ridge National Laboratories; Jim Henrie in catalyst testing at Rockwell Hanford Operations; and Jay Duckett in cask handling and loading equipment testing at Westinghouse Hanford Company. Also, considerable efforts were expended by the U.S. Nuclear Regulatory Commission in review of cask licensing documentation and in oversight of TMI-2 site operations; by the railroad companies in train makeup, movement, and switching operations; by the American Association of Railroads and the U.S. Department of Transportation in review of railroad operations; and by many other organizations, all of whom contributed significantly to the overall success of the program.

From a different perspective, we give credit to the vast array of public officials and private parties who were notably persistent in questioning to gain an understanding of the safety aspects of the TMI-2 core debris transport activity—this document will disclose that parts of the activity were altered as a result of public interaction. Of those who probed most thoughtfully and thoroughly, we identify U.S. Senators John Heinz (deceased), Pennsylvania, and John Danforth, Missouri; Congressmen William Clay, Missouri, Jack Buechner, Missouri, Richard Gephardt, Missouri, Alan Wheat, Missouri, and Jim Slattery, Kansas; Governors John Ashcroft, Missouri, Robert Kerrey, Nebraska, Cecil Andrus, Idaho, and James Thompson, Illinois; and private parties/organizations Kaye Drey, Missouri (Citizens Against Radioactive Transport); Liz Paul, Idaho (Snake River Alliance); Marvin Resonikoff (Sierra Club Radioactive Waste Campaign); mayors such as Vincent C. Schoemehl, Jr., St. Louis; city officials such as Gay Carraway, St. Louis, Director of Public Safety; and media representatives such as Mark Roth, *Pittsburgh Post-Gazette*, and Rocky Barker, Idaho Falls *Post Register*. We also want to acknowledge the value of the efforts and the able

assistance of the governors' designees; the support of other State workers, such as Richard Ross, Missouri, was much appreciated.

The above only begins to identify all those who were involved in the conduct or examination of the TMI-2 core debris shipping campaign. For those not mentioned, we express appreciation for their efforts and regret omission of individual acknowledgments. Since we seek to recognize the broad range of contributions this campaign benefited from, the documented efforts of many contributors and involved parties are provided in references, appendices, or tabulations of this report.

Also, we urge the readers to read the references since full credit is not always provided for the thoughts, sentences, paragraphs, and even full pages of text liberally borrowed from reference documents. We intend no offense, but for the sake of easy readability, many credits are purposely omitted for previously written words that have been either restated, or used directly in this report.

About the authors —

Richard C. Schmitt was the program manager of the TMI-2 Fuel and Waste Handling Program. He worked at the Idaho National Engineering Laboratory (INEL) and assumed programmatic responsibility for completing the objectives of the DOE/GPU Nuclear core contract on behalf of DOE in February of 1985. His responsibilities included EG&G Idaho activities in cask acquisition, establishment of canister acceptance requirements, and preparations at the INEL to receive the TMI-2 core debris. He directed transport-related activities performed at TIO as well as at the INEL. Throughout the campaign, funding and conduct of operations focused through his office in Idaho.

Geoffrey J. Quinn was the initial EG&G Idaho senior project engineer located at TMI-2 with responsibilities related to establishing the working relations and procedures by which the core debris shipping campaign would function. Mr. Quinn's responsibilities included cask acquisition, coordinating handling equipment interfaces, and integrating the licensing effort involving GPU Nuclear and Nuclear Packaging in obtaining approval from the Nuclear Regulatory Commission. Mr. Quinn left the program in 1986 after shipments were initiated. He is presently an employee of Wastren, Inc.

Michael J. Tyacke was a project engineer initially with responsibilities at TMI-2 in the preparations to transport the core debris, especially in ensuring that canisters met the INEL's acceptance requirements, and later, for the last half of the campaign, was the project engineer at the INEL, in receipt and storage operations.

Collectively, the authors have worked over 24 years on various activities of the TMI-2 accident recovery program; two of the authors supported the entire TMI-2 core debris shipping campaign.

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FIGURES

TABLES

ACRONYMS

A&S	Alton and Southern Railways
AAR	Association of American Railroads
ALK	ALK Associated, Inc.
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AVLT	assembly verification leak test
B&PV	ASME Boiler and Pressure Vessel Code
B&W	Babcock & Wilcox
CFA	Central Facilities Area
CFR	Code of Federal Regulations
CHLA	cask hydraulic lift assembly
CoC	Certificate of Compliance
CSX	Chessie System Railroad (a unit of CSX Corporation)
CUS	cask unloading station
DOE	U.S. Department of Energy
DOE-DP	DOE Defense Program
DOE-HQ	DOE Headquarters
DOE-ID	DOE Idaho Field Office
DOE-NE	DOE Office of Nuclear Energy
DOP	detailed operating procedure
DOT	U.S. Department of Transportation
EIS	Environmental Impact Statement
EPRI	Electric Power Research Institute
FHB	Fuel Handling Building
FOIA	Freedom of Information Act
FRA	Federal Railroad Administration
FTC	fuel transfer cask
GAO	U.S. General Accounting Office
GEND	General Public Utilities Corporation, Electric Power Research Institute, NRC, and DOE, collectively
H&V	heating and ventilation
HECF	Heavy Equipment Cleaning Facility
HEDL	Hanford Engineering Development Laboratory
HEPA	high efficiency particulate air
ICV	inner containment vessel
INEL	Idaho National Engineering Laboratory
LWT	legal-weight-truck
MASF	Maintenance and Support Facility
MHC	mini-hot cell
MOU	Memorandum of Understanding
NAC	Nuclear Assurance Company
NRC	U.S. Nuclear Regulatory Commission
NuPac	Nuclear Packaging, Inc.
O&M	operations and maintenance

OCRWM	DOE Office of Civilian Radioactive Waste Management
OCV	outer containment vessel
ORNL	Oak Ridge National Laboratory
OSRD	Operational Safety Requirements Document
PDSR	Post-Defueling Survey Reports
QA	quality assurance
R&D	research and development
RFP	request for proposals
RHO	Rockwell Hanford Operations
SAIC	Science Application International Corporation
SAR	safety analysis report
SARP	safety analysis report for packaging
SCLC	shipping cask loading collar
SD	system design
SER	safety analysis/safety evaluation report
SNL	Sandia National Laboratories
SNM	special nuclear material
SOP	standard operating procedure
TAN	Test Area North
TCB	Transportation Certification Branch
TIO	Technical Integration Office
TER	technical evaluation report
TMI-2	Three Mile Island Unit 2
TSB	Technical Support Branch
TTC	Transportation Technology Center
UP	Union Pacific Railroad
USC	United States Code
UWI	unit work instruction
WHC	Westinghouse Hanford Company

Historical Summary of the Three Mile Island Unit 2 Core Debris Transportation Campaign

1. INTRODUCTION

This report describes the Three Mile Island Unit 2 (TMI-2) core debris transportation campaign. The campaign consisted of 22 rail shipments (trains) resulting in the transport of 49 casks loaded with 342 canisters of TMI-2 core debris. The shipments traveled on a route from TMI-2 through St. Louis, Missouri, to the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. The shipments occurred from July 1986 until April 1990. Although there were no serious incidents or accidents involving damage to the casks or trains during the campaign, public interest in the shipments was substantial.

The activities comprising the campaign are described in roughly chronological order. Preparations to transport (ship)[a] the core debris are described to provide the background for decisions made for equipment selection and logistical approaches. Section 2, on precampaign activities, is followed by discussions of the actual transport operations. From preparations at TMI-2 to receipt and storage at the INEL, this section includes changes in operations made in reaction to technical requirements or influenced by public reaction to the shipping campaign. The next section discusses lessons learned from the campaign. A final section addresses post-campaign activities during storage of the core debris materials.

This report does not address the large parallel effort at the INEL to prepare the equipment and tooling that was required to examine samples of the core debris (i.e., handle and open canisters, remove core materials, and investigate the condition of the samples). Also not addressed are the analytical activities of the Accident Evaluation Program, which used the results of the core debris material examination efforts and added those results to all other data obtained from the investigation of the accident, to fully understand the core damage sequence. Nor does this report provide information on TMI-2 defueling tooling and operations other than those basics needed to understand the core shipping interface. For the reader with an interest in pursuing these subjects, references are provided.

a. Ship (shipping, shipment) and transport are used interchangeably within this document.

2. PREPARATIONS FOR THE TRANSPORT CAMPAIGN

Preparations for the TMI-2 core debris transport campaign were extensive and spanned several years. This section describes major organizational roles and responsibilities that broadly defined the scope undertaken by each of the participants of the program; overall program and logistics planning that took the objective and identified the detailed tasks that were necessary; defueling operations and core debris canisters that were at the center of the systems engineering aspects of the program; cask procurement, development, testing, fabrication, and certification that firmly established the ability of the cask to provide for the safety of the public during transport; TMI-2 and INEL site facility modifications that were essential for efficient cask handling, loading, and unloading; railroad carrier preshipment preparations; and activities related to institutional issues that preceded the start of transport operations.

2.1 Organizational Roles and Responsibilities

Many organizations participated in the TMI-2 core debris shipping campaign. The U.S. Department of Energy (DOE) and its subcontractors were ultimately responsible for shipping and receiving operations. GPU Nuclear Corporation and its subcontractors were responsible for preshipment operations at the TMI-2 site. DOE became responsible for core transport activities as an extension of its capability to safely handle, examine, and store highly radioactive core materials from experimental reactors.

From the development of the first nuclear power reactors, DOE (and its predecessor agencies) has had an interest in studying reactor safety. The sequence of events in severe reactor accidents has been evaluated analytically and then experimentally verified to better predict damage scenarios, and thereby prevent accidents or mitigate consequences. The TMI-2 accident on March 28, 1979, represented one of the most severe integral tests of commercial nuclear plant safety philosophy and safety systems performance ever encountered in a commercial light water reactor. The result was a unique opportunity for the nuclear industry to advance its understanding of plant behavior during and after a severe core damage accident. The TMI-2 accident provided information that was not previously available through other severe accident research, development, and test programs.

In December 1979, as part of President Carter's statement on the findings of the President's Commission on the Accident at Three Mile Island (John G. Kemeny, Chairman), DOE was charged with the responsibility of implementing a research and development (R&D) effort related to the accident.[1] This responsibility would eventually lead to DOE's TMI-2 core debris transport campaign.

The General Public Utilities Corporation,[b] Electric Power Research Institute (EPRI), U.S. Nuclear Regulatory Commission (NRC), and DOE, collectively identified by the acronym GEND, recognized the unique R&D opportunities at TMI-2, and in March 1980 signed a Coordination Agreement establishing the Technical Information and Examination Program. As shown in Appendix A, the Coordination Agreement identified the objectives to which the participants subscribed and defined, in broad terms, methods to achieve the objectives consistent with the other obligations of the participants.

In March 1981, NRC published an Environmental Impact Statement (EIS), which concluded that the core debris and other high-specific-activity radioactive waste materials should be removed from the TMI site because the location, geology, and hydrology of the site did not meet

b. General Public Utilities Corporation was the plant owner when the Coordination Agreement was signed. Since January 1982, TMI has been operated by GPU Nuclear Corporation (hereafter identified as GPU Nuclear in this document), a subsidiary of the General Public Utilities Corporation.

the criteria for a safe long-term storage/disposal facility.[2]

From the beginning, DOE's TMI-2 Program received overall direction from offices within the Assistant Secretary for Nuclear Energy at DOE Headquarters (DOE-HQ) and was managed by the DOE Idaho Field Office (DOE-ID). Initially, DOE's efforts at TMI-2 emphasized the performance of general R&D programs aimed at establishing the causes and consequences of the accident. However, in March 1981, the U.S. Secretary of Energy wrote a memorandum to the President of the United States outlining an expanded R&D role for DOE in which DOE would expedite the acquisition of general information from TMI-2 through accelerated core removal (see Appendix B).

In a memorandum to the Secretary of Energy dated March 20, 1981, the President approved the DOE request to amend its civilian nuclear budget in Fiscal Year 1982 to include enhanced R&D activities at TMI-2 (see Appendix B). DOE's role was expanded to include supporting the utility's efforts towards gaining early access to the core to assess the extent of damage; and the development of procedures to effect core removal, packaging, and shipment to a DOE site for storage and examination. Based on the President's memorandum and reflecting this commitment, the DOE program was expanded and reorganized to include the added activities. In October 1981, in a letter from Counselor Edwin Meese, III, to Pennsylvania Governor Richard Thornburgh, the administration reiterated its support of DOE's R&D role (see Appendix B).

In addition to gaining responsibilities from the President to provide support in the development of core defueling and shipping capabilities, DOE needed to formalize working relationships with NRC to actively participate in the cleanup, since NRC was the regulator responsible for safety oversight at the TMI-2 commercial nuclear reactor site. This was accomplished in July 1981 when NRC and DOE signed an interagency Memorandum of Understanding (MOU) specifying the procedures to help ensure that TMI-2 would not become a long-term waste storage or disposal site. The roles and responsibilities of NRC and DOE in the MOU were updated in a March 1982 revision to reflect DOE's agreement to accept the entire TMI-2 damaged core for R&D and storage at a DOE facility (see Appendix B). Also, around this time, DOE was in the early stages of accepting responsibility for disposal of all spent nuclear fuel from commercial reactors.[3]

The INEL was recognized for its work in reactor operations and severe accident safety research, and had the most suitable DOE facilities to receive and examine the TMI-2 core debris. For these reasons, DOE selected the INEL to perform the TMI-2 core debris investigations. EG&G Idaho, Inc. (EG&G Idaho), acting on behalf of DOE, managed the TMI-2 Information and Examination Program (hereafter referred to as the TMI-2 Program).

GPU Nuclear, as the operator of the damaged reactor, was responsible for TMI-2 site activities performed during the cleanup. Bechtel Corporation (Bechtel) and its subsidiaries were hired to assist as the major subcontractor for the engineering support to the cleanup operations. The Babcock and Wilcox Company (B&W), the TMI-2 reactor steam system supply company, supported Bechtel in cleanup operations, including core debris canister design.

The major organizations in the TMI-2 cleanup program were supported by numerous technical specialists. EG&G Idaho's management of the TMI-2 Program relied on a DOE-wide cadre of experts familiar with the safe handling of high-specific-activity nuclear materials. By early 1983, following DOE's agreement to accept the entire TMI-2 core, the TMI-2 Program initiated a set of coordinated activities to prepare to transport the core debris from TMI-2 for scientific investigations and to store the materials at the INEL. These activities included drafting and negotiating DOE's contract with GPU Nuclear for transportation, storage, and disposal of the TMI-2 core; evaluating handling and storage requirements for the core debris at the INEL site;

and assessing options for core debris transport packages and logistics.

During these activities, extensive interfaces developed between EG&G Idaho's on-site staff at TMI and the home-office staff at the INEL; between EG&G Idaho/DOE and GPU Nuclear and its contractors; with consultants and working groups; with experts from other DOE national laboratories; with NRC; and with many other outside parties, such as the Citizens Advisory Group from Harrisburg, Pennsylvania.

The technical side of these interfaces eventually established the guidelines by which the TMI-2 core debris would be packaged for transport, the kind of handling equipment each facility would need, and much of the logistical framework for the transport operations. Many alternatives would be examined and many perturbations would occur before decisions were final. This was a time of rapid technical change and progress in the cleanup at TMI-2, and what appeared reasonably certain at one particular time could experience notable change soon thereafter, as the result of new information on core damage conditions, plans for defueling operations, or other changes in technical constraints. For the participants, 1983 to 1986 was a time of rapid evolution in the needs to be considered in preparing for safe transport of the TMI-2 core debris.

2.1.1 DOE/GPU Nuclear Core Contract. In March 1982, DOE-HQ and GPU Nuclear signed an Agreement in Principle that DOE would acquire the TMI-2 reactor core debris (see Appendix B). In August 1982, DOE-HQ requested DOE-ID to develop a contract with GPU Nuclear to take title to the TMI-2 core debris for performing the core-related R&D objectives of the TMI-2 Program. Although it would be early 1984 before the contract was executed, in the interim, the Agreement in Principle and drafts of the contract reflected the eventual responsibilities agreed to between DOE and GPU Nuclear. In March 1984, DOE/GPU Nuclear's Core Acquisition Contract, Number DE-SC07-84ID12355, "Transportation, Storage, and Disposal Service for the TMI-2 Reactor Core," was finalized. The contract, which formally delineated the responsibilities for the various parties, was known simply as the core contract, and with it DOE and GPU Nuclear agreed that:

- DOE shall procure and provide the transportation, storage, and disposal of the core materials delivered under the contract, including carrier and casks, and shall meet all applicable requirements for shipping core materials
- GPU Nuclear shall provide canisters, packaging, required inspections, loading activities, and other preparations required to ensure compliance with all laws and regulations applicable to shipment of the core material.

The core contract specified a number of terms, conditions, and charges that applied to the transport program, including:

- All core material removed from the reactor vessel or associated piping could be delivered to DOE
- Delivery of the core material was to be made by GPU Nuclear free on board[c] commercial conveyance at the TMI-2 plant site
- Both parties were to mutually agree on shipping schedules
- GPU Nuclear was to concur in areas of its own responsibility, such as in licensing and safety
- GPU Nuclear was to notify DOE nine months before the proposed date for the first shipment
- GPU Nuclear was to begin delivery by July 1, 1986, and complete delivery by December 31, 1987

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c. DOE, not GPU Nuclear, was to pay for the cost of transporting the conveyance (vehicle carrying the core debris).

- Each canister of core debris was to be shipped within 90 days after removal of the material from the reactor vessel

- DOE accepted title to the material "as is" when DOE signed the shipping papers (often interpreted to imply acceptance at the "TMI site boundary or gate")

- DOE had the right to dispose of the material as it saw fit without liability, or compensation, to GPU Nuclear

- GPU Nuclear was to pay $7,351,128 to DOE for DOE's services in transporting and storing the core (an amount based on projected charges to send spent fuel to a Federal repository; see Section 3.4.2 for contract amendments and final contract value)

- Both parties assumed that a total of 238 canisters would be needed for the entire core, resulting in a payment of $30,887 for each canister delivered

- In the event that delivery to DOE was to occur after March 31, 1988, GPU Nuclear was to be responsible for full cost recovery of DOE's costs for receipt and handling.

The contract included three appendices. Appendix A of the contract identified the core material as that contained inside the baffle plates of the original configuration of the reactor. Figure 2-1 shows a cross-section of the reactor vessel and one of the 177 fuel assemblies originally in the core. The core material included the fuel assemblies and all fuel rods, control rods, axial power shaping rods, guide tubes, instrumentation tubes, spacer sleeves, spacer grids, end fittings, control rod spiders, and coupling mechanisms. The core materials excluded support structures (e.g., lower support plate and thermal shield) but allowed provisions for such materials when other structural materials "may have become inseparably mixed" with the core materials. As will be discussed later, negotiations permitted some special materials needed for defueling operations to be accepted (e.g., diatomaceous earth used to aid filters that removed fine fuel particles during cleanup of reactor vessel water).

Appendix B of the core contract listed information and data requirements that each party was responsible for and specified a date when the information was due. (See Appendix C of this report for a copy.) More than 20 information and data deliverables were specified as a result of a thorough evaluation of the needs of DOE and EG&G Idaho for acceptance of the TMI-2 core. The deliverables represented a first approximation of the extent of the documentation that both parties would develop for the equipment and procedures for the core transport program. The contract further required each party to promptly communicate changes to any already supplied information.

Appendix C of the core contract specified the criteria for acceptance of a shipment at TMI-2 and included requirements for information on shipping papers, limits on external radiation and contamination levels, and conditions for criticality control during canister handling and storage in unborated water.

The above responsibilities of GPU Nuclear and DOE, as specified in the contract, were a continual source of guidance to working-level engineers during the significant amount of developmental activities needed to prepare for and conduct the transport campaign. Many technical discussions on alternatives in equipment design, operating procedures, and administrative methods were guided by the core contract, which was the source document for programmatic requirements for TMI-2 core debris transport.

2.2 TMI-2 Core Shipping Program Plan

Prior to the agreement with DOE to accept the core debris, and before the extent of core damage was known, GPU Nuclear had investigated transport options.[4] After the Agreement in Principle was signed between DOE and GPU Nuclear but before the core contract was final, planning activities leading to the transport program had been

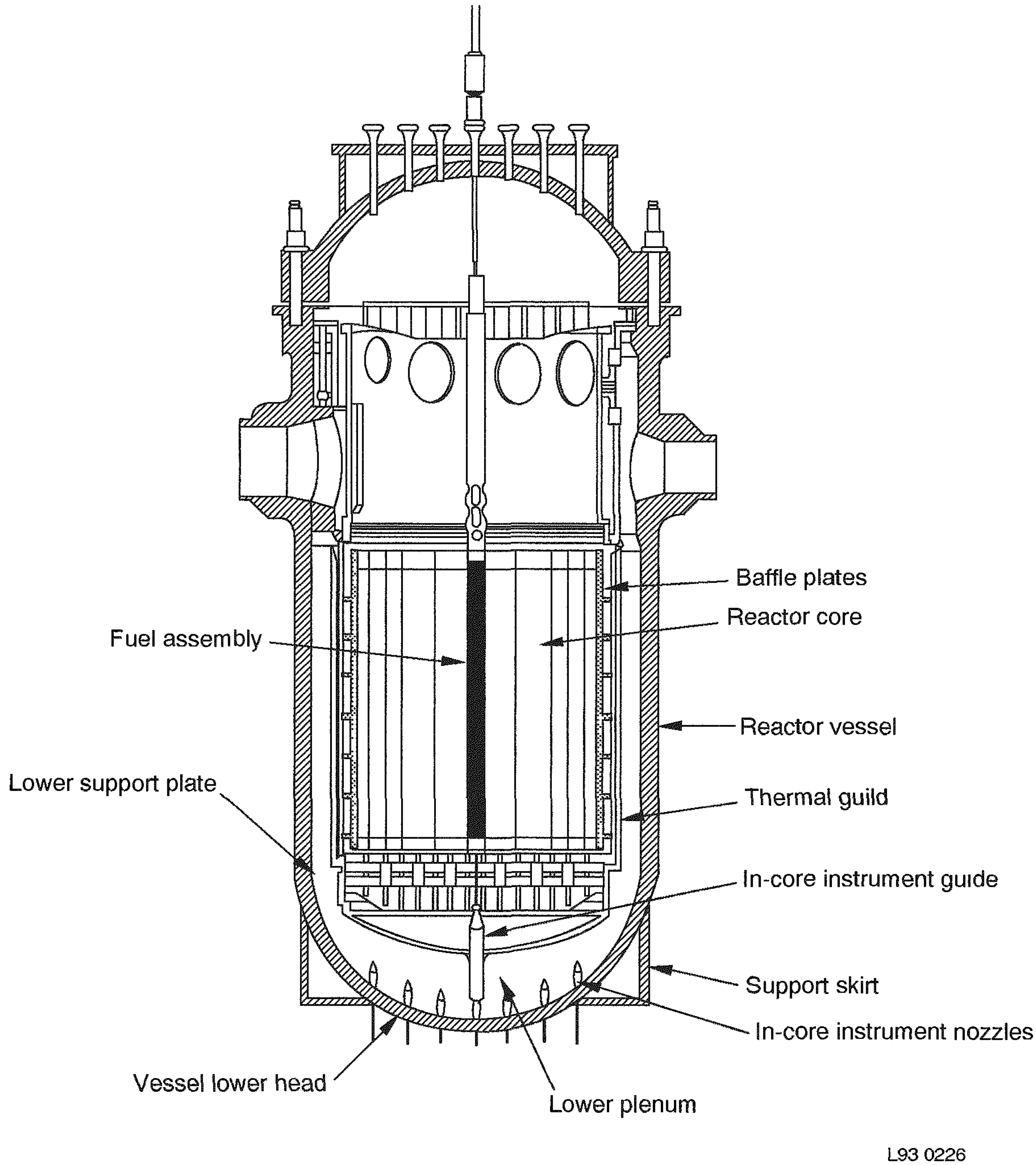

Figure 2-1. TMI-2 reactor vessel cross-section.

initiated by both EG&G Idaho and GPU Nuclear. Engineering studies were performed by the staffs at both the TMI-2 and INEL sites on approaches for handling canisters containing the core debris and for handling and loading the shipping casks.

Crucial to the transport program was a description of what was to be shipped. GPU Nuclear proceeded to systematically gain access to the core, obtain samples of core debris materials, design equipment for defueling, and develop canisters. In parallel with GPU Nuclear's activities, EG&G Idaho performed a review to determine the requirements that would apply assuming that EG&G Idaho, functioning as the operating subcontractor for DOE, would accept title to the core debris and become the shipper of record for transport of the core debris from TMI-2 to the INEL. Requirements were published in August 1983 that addressed the areas of accountability, security, quality, safety, environment, and transportation.[5]

Recognizing their mutual obligations for ensuring that cost-minimizing approaches be used at both places for selection of the handling equipment and assignment of support personnel, EG&G Idaho and GPU Nuclear began integrating their separate engineering activities for core debris transport in early 1983. Working relationships were reflected in a TMI-2 Core Shipping Program Plan issued by EG&G Idaho, which documented the close coordination needed for preparations at both TMI-2 and the INEL.[6]

The objectives from the program plan were as follows: (a) prepare for safe shipment, receipt, and storage of the core debris; (b) as soon as practicable after the start of defueling, begin transporting and storing canisters at a rate that would allow completion within the shortest economically feasible timeframe; (c) make core debris available for research in a timely manner; and (d) minimize costs consistent with the objectives and schedules of the program. The plan established the coordination between TMI-2 and the INEL (and others) and provided the mechanism by which handling systems for core debris at both locations were designed, constructed, or modified for system compatibility. The Core Shipping Program Plan further elaborated the organizational responsibilities of both EG&G Idaho and GPU Nuclear that were established during the core contract negotiations.

GPU Nuclear and its contractor, Bechtel, were to be responsible for planning and implementing the loading of core debris into canisters, preparing canisters for shipment, loading canisters into transport casks, and preparing casks for transport. Preparations for safe shipment included removing water from canisters, decontaminating canister external surfaces, and other steps necessary to control hazards during cask loading, transport, and unloading. Necessary shipping documentation was also to be completed. Selection and licensing of loading methods and canisters were a GPU Nuclear responsibility. Bechtel, on behalf of GPU Nuclear, selected Westinghouse Electric Corporation as the support contractor for defueling equipment to load core debris canisters. B&W was selected as the contractor for canister design, safety analysis, and licensing.

EG&G Idaho, on behalf of DOE, was responsible for managing the transport program with DOE the shipper of record. EG&G Idaho selected the cask supplier and managed technical support for cask development provided by DOE's national laboratories. In August 1984, EG&G Idaho selected Nuclear Packaging, Inc. (NuPac) to provide two rail casks. NuPac was responsible for preparing and submitting the safety analysis report (SAR) for the shipping cask to NRC [also referred to as safety analysis report for packaging (SARP) in the literature]. DOE contractors Rockwell Hanford Operations (RHO) and the Sandia National Laboratory (SNL) Transportation Technology Center (TTC) provided technical support to the cask supplier for licensing submittals in radiolytic gas controls and scale-model cask testing, respectively. SNL TTC provided an independent review of the SAR for EG&G Idaho. The TMI-2 Technical Support Branch (TSB) of EG&G Idaho at the INEL made the necessary preparations for receipt of core debris at the INEL.

The plan also noted that the DOE-ID safety organization was responsible for reviewing and approving the SAR prepared by EG&G Idaho for transport of the TMI-2 core debris across the INEL site, and for ensuring that DOE's safety and environmental protection requirements were satisfied. The plan identified NRC as the certification authority for the cask and as the performing organization for TMI-site preshipment inspections of the loaded casks.

2.2.1 Core Shipping Technical Working Team. In September 1983, EG&G Idaho requested that GPU Nuclear consider a cooperative coordination effort for the TMI-2 core debris transport program in the form of a Core Shipping Technical Working Team. EG&G Idaho had drafted the Core Shipping Program Plan during negotiations between DOE and GPU Nuclear on the core contract. The plan recognized that coordination was required because of the broad scope, number of organizations involved, and interfaces required. The Core Shipping Technical Working Team was responsible for coordinating information between member organizations preparing for shipment of the TMI-2 core.

The team provided a focal point for each program task, where activity status could be exchanged and potential problems could be identified for resolution in a timely manner. Table 2-1 shows the organizational representation to the team as proposed in the program plan. These principal organizations, and occasionally other special support organizations, attended the regularly held team meetings, during which many attendees would hear of progress on program tasks. The contributions of the attendees were essential to the success of the program.

The team met first in late 1983 and approximately every six to eight weeks for the following two years. The team meetings were highly successful in efficiently exchanging accurate and timely information. Meeting minutes included items discussed, copies of overhead slides used in presentations, and lists of action items assigned to attendees based on the discussions. Comprehensive meeting minutes allowed attendees to return to their own organizations and distribute the information to the many persons not able to attend team meetings but in need of current communication on technical changes in the program. Many of the issues identified at the team meetings and tracked to resolution are described in other sections of this report.

2.3 Canister Designs

The design of a canister for transport of damaged core material was an early technical consideration in cleanup from the accident.[4] Even before any visual assessment had been made of the extent of damage to the core, failure of fuel rod cladding in some fuel assemblies was evident from various indicators, including the radioactivity released into the plant's cooling water. Degraded fuel assemblies, debris, and sections of fused core materials were considered to be the potential forms of the materials needing to be placed into canisters for on-site storage. Canisters would provide structural integrity for moving materials out of the reactor vessel, controlling the spread of radioactivity from the damaged fuel to the spent fuel storage pool, and ultimately containing the materials during transport.

Table 2-1. Programmatic representation to the TMI-2 Core Shipping Technical Working Team.

Program task	Responsible organization
Program management	EG&G Idaho TMI-Site Office
Core defueling coordination	GPU Nuclear/Westinghouse
Canister design coordination	GPU Nuclear/B&W
TMI facility preparation	GPU Nuclear/Bechtel
Cask supply	EG&G Idaho TMI-Site Office/ Nuclear Packaging, Inc.
Hazards identification	RHO
Shipping approvals	DOE-ID and NRC
Transportation technology	SNL TTC
Transportation support	EG&G Idaho TMI-Site Office/TSB
INEL facility preparation	EG&G Idaho TSB

Thus, long before DOE had agreed to accept the entire core for examination, GPU Nuclear was evaluating the design of canisters for damaged fuel assemblies. Canister design was recognized as directly related to technical approaches for defueling operations and tooling to be used in each approach. Canister design was also known to be directly related to the options for the transport cask and would dictate many fuel debris storage equipment decisions either on-site at TMI-2 or at any storage location. As reflected in the core contract, canister design was at the heart of a systems integration problem on how to handle, transfer, and store the canisters at a minimum total cost to both GPU Nuclear and DOE.

Early in the cleanup, limited direct information on the extent of damage to the TMI-2 core resulted in substantial difficulties in making the systems engineering types of decisions required for defueling equipment and canisters. Even the very wide range of related support equipment that awaited such decisions cannot be understated. At first, firm technical information on which to base decisions on the type of defueling equipment needed (and hence types of appropriate canisters) was simply not available, although assumptions as to the extent of damage were being made.[2,4,7] Not until the Quick Look activity in July 1982 was a miniature camera inserted into the TMI-2 reactor vessel and the severity of the damage to the core visually verified.[8] Post-accident core materials and geometry were significantly altered from the originally installed core. Proceeding with development of defueling equipment based on actual conditions only became possible after the Quick Look,[8] subsequent mapping of the damaged core's topography by ultrasonics in September 1983,[9] obtaining of grab samples from the debris bed in September 1983,[10] and probing of the core debris bed by experiments in December 1984.[11]

Eventually, core damage investigations would disclose the end state of the accident as shown in Figure 2-2: a severely degraded core with a large void in the upper region of the original core, a bed of rubble, and only two intact full-length fuel assemblies at the periphery of the core. Initial direct examinations confirmed previously suspected conditions but, as importantly, allowed design of the defueling system to progress without hesitation due to resolution of large uncertainties in actual core conditions. This progress helped with the systems engineering decisions needed to bring the defueling equipment, canisters, canister-handling equipment, transport cask, and INEL storage equipment from conceptual designs to working hardware.

As described more fully in Section 2.4.1, decisions regarding suitability of a transport cask for the TMI-2 core debris at first included consideration of a potential need to transport full-length fuel assemblies. Canisters were expected to be needed for some to many still-standing assemblies with only degraded fuel rod cladding (leakers). Realization in early 1984 that shorter canisters (less than the full-length of an intact fuel assembly) could be used will be shown to have significantly changed the approach to the equipment for the core debris transport campaign. The following discussion describes the defueling operations and the final design of the core debris canisters as actually used during cleanup of TMI-2.

2.3.1 Defueling Operations. The condition of the damaged core prevented use of the normal method of grappling the top of a fuel assembly for movement out of a core and into a spent fuel shipping cask. There were lengths of broken fuel rods and loose fuel pellets scattered about the top of the rubble bed. Options for removal of such materials involved principally either "pick-and-place" or "vacuum removal" types of defueling methods. Large pieces, like partial-length fuel assemblies and control rod spiders, were big enough to be picked up and placed directly into an open-top fuel canister (see descriptions of canister types below). Smaller pieces were picked up and placed into a small rectangular basket that was itself placed into a fuel canister. Even smaller items, like fuel pellets and fine fuel materials, were able to be hydraulically vacuumed up and out of the damaged core.

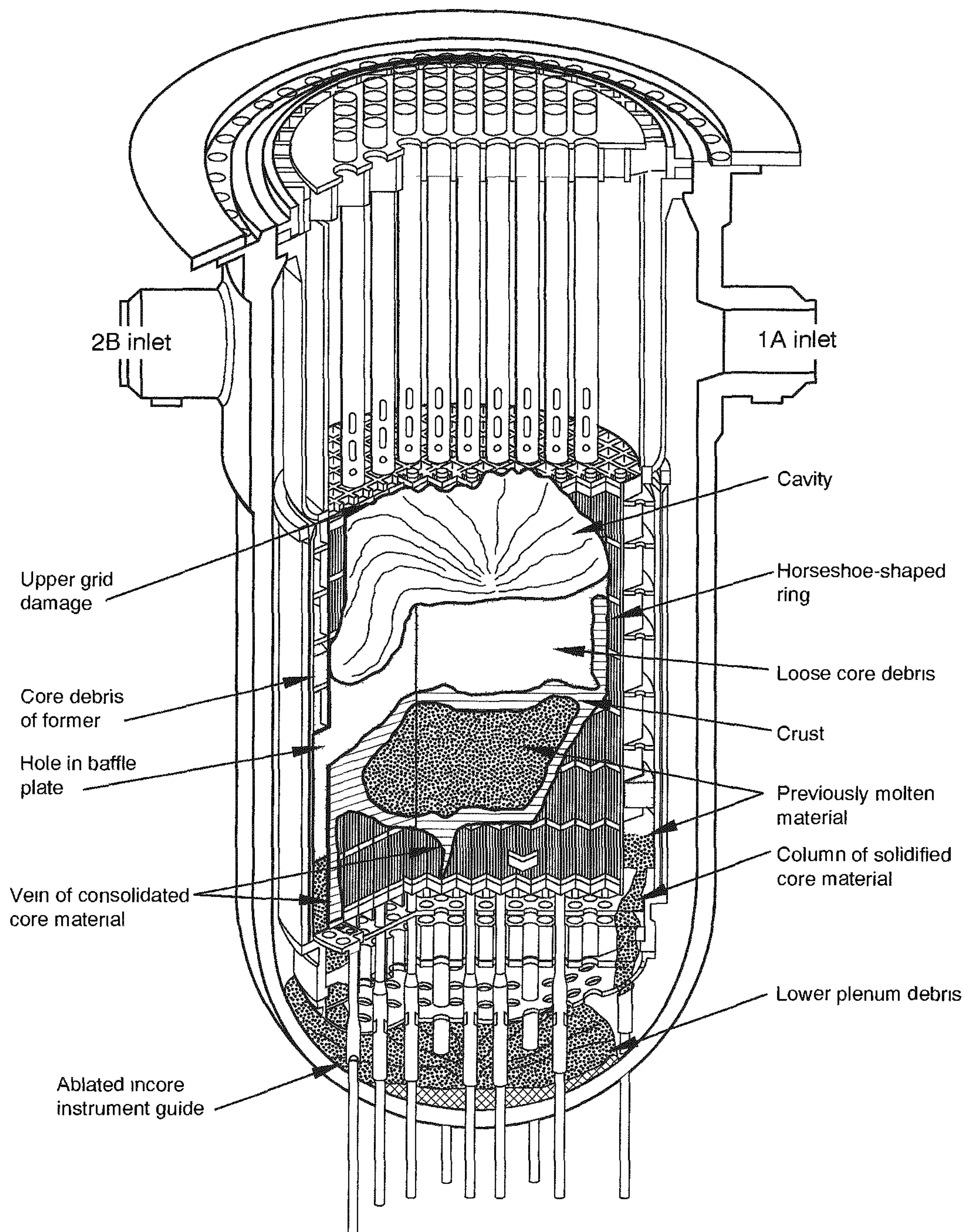

Figure 2-2. End state configuration of the TMI-2 reactor vessel and core.

These two types of removal operations were conducted from a platform built above the top of the open reactor vessel. As shown in Figure 2-3, the shielded work platform allowed defueling operators to stand directly above the damaged core.[12] From this position, long-handled tools were inserted into the core to move and manipulate the debris.[13,14] Pick-and-place operations and vacuum defueling operations were eventually complimented by use of a core-boring machine that was able to bore through the once-molten materials that solidified into large masses at different locations in the reactor vessel.[15,16] Various combinations of pick-and-place, vacuum removal, and large-item size reduction enabled the operators to load the core into canisters for removal from the TMI-2 site.

Loaded canisters were removed from the reactor vessel using a dry transfer system. Figure 2-3 shows conceptually how the loaded canisters were lifted out of the water in the reactor vessel into a shielded transfer device. From there, the canisters were taken to the refueling canal and lowered from the shield back into the water into an upender. After rotation from vertical to horizontal, canisters were transferred through the existing facility fuel transfer tube from the reactor building to the Fuel Handling Building. After being returned to vertical, each canister was placed into a storage position in a rack to await preparations for loading into a shipping cask.

2.3.2 Canister Types. Defueling operations required three types of canister designs for the TMI-2 core debris: fuel canister, knockout canister, and filter canister. Fuel canisters contained larger pieces of core debris up to partial-length, full cross-section fuel assemblies. Knockout canisters contained loose core rubble of a size small enough to be vacuumed up from the rubble bed. Filter canisters contained small fuel fines removed by many filter elements from the water circulated through the vacuum defueling system and the defueling water cleanup system.

The three canister designs are shown in Figure 2-4. All three types of canisters had the same length, diameter, and lower head design, but different internal components. Each was 381 cm (150 in.) in overall length. Each had an outer

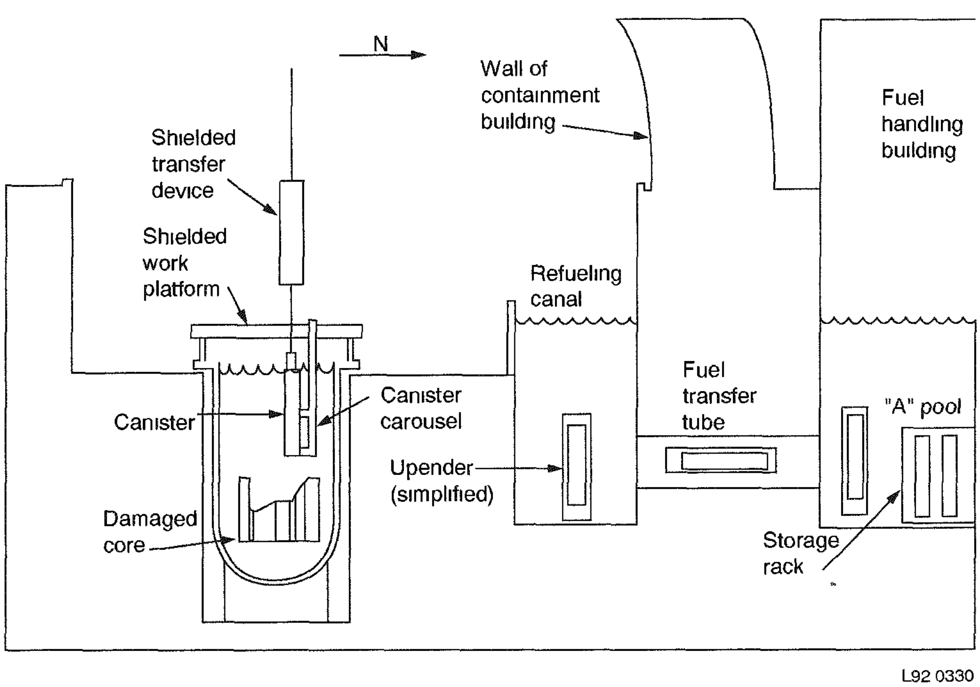

Figure 2-3. Schematic showing transfer of loaded canister from reactor vessel through fuel transfer tube to storage rack in the pool "A" of the Fuel Handling Building.

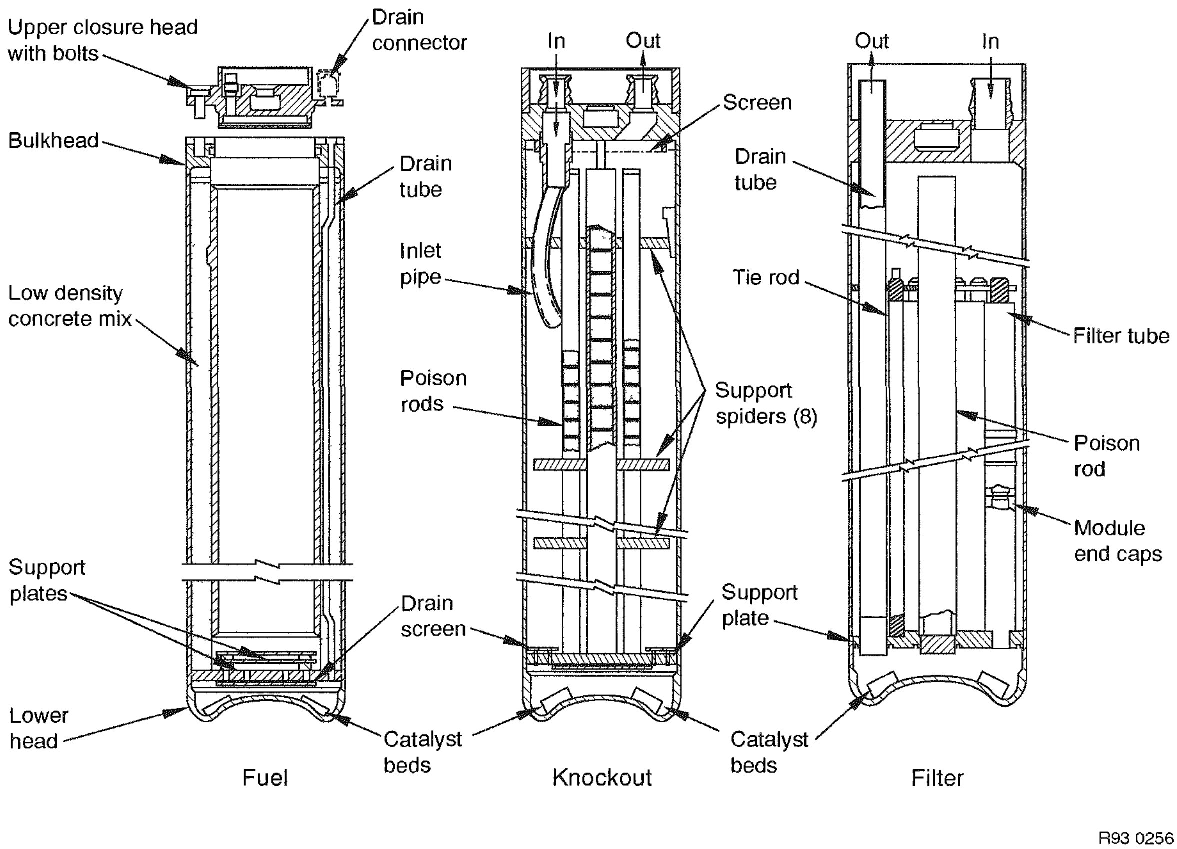

Figure 2-4. Core debris canisters.

shell fabricated of 304L stainless steel pipe that was 36 cm (14 in.) outer diameter with a 0.64-cm (0.25-in.) -thick wall. The lower head was a reversed-dish design welded to the body. A flat upper head was bolted to the fuel canister body for closure and welded to the body of the knockout and filter canisters. All canisters had penetrations in the upper head that allowed for dewatering and interfacing with a grapple on the canister-handling equipment. Knockout and filter canisters also had penetrations for hydraulic (vacuum removal) defueling operations. Another feature common to all three types of canisters was the use of beds of recombiner catalysts inside the upper and lower heads of each canister. The catalysts recombined hydrogen and oxygen gases formed by radiolytic decomposition of water in wet core debris.

EG&G Idaho imposed requirements specific to the receipt of canisters in light of constraints at the receiving and storage facility.[17] These technical requirements included a limit on the maximum weight of a loaded canister of 2,800 lb with no more than 5% of the total number of canisters allowed to exceed this value by 5% or weigh up to 2,940 lb. The weight restriction was based on floor loading considerations in the INEL storage pool (see Section 3.3.2.3 for changes to this criterion).

Fuel canisters had a removable head for inserting large pieces of fuel debris directly into the square cavity. Partial-length, full cross-section assemblies up to 3.5 m (136 in.) long could be loaded into a fuel canister with "pick-and-place" defueling tools. Also, a fuel canister cavity could accept several of the small baskets loaded with lengths of broken rods or other small items still too large to remove by the vacuum defueling system.

Knockout and filter canisters were loaded by the hydraulic vacuum removal system. The design of the knockout canister filtered particles out of water flowing through the vacuum removal system by controlling the flow velocities internal to the canister and by establishing centrifugal forces by swirling the inlet flow. Centrifugal forces kept the particles toward the outer diameter of the canister and away from the exit flow near the center of the upper head. Also, the upward flow velocity was less than the velocity required to transport larger-sized particles, considering the force of gravity. A filter screen acted as a secondary filtration device to limit the size of particles allowed to leave a knockout canister and enter a downstream filter canister.

Filter canisters were used in the vacuum removal system to remove particles 850 μ and smaller from the flow stream. These canisters were also used in the defueling water cleanup system for the same purpose. In either system, water containing small fines entered the filter canister through an inlet nozzle on the upper head. The slurry flowed down into a full-diameter mixing chamber that was 30.5 cm (12 in.) long at the top of the canister. From the chamber, the slurry flowed down and around filter bundles consisting of a stack of 17 filter elements. Each filter element was made of sintered stainless steel filter media with corrugated pleats around a perforated core tube. The water flowed from the outside through the filter media and into the center tube, which directed the filtered water down into the lower head. The flow then went up a drain tube and out a nozzle on the upper head.

Other features of the canister design are seen in Figure 2-4. Criticality control structures were provided in a fuel canister by a boral shroud held in place by bulkheads and by a low density concrete mix with the tradename of LICON. In both the knockout and filter canisters, criticality control was provided by poison rods and their supports. Canister features important to transport safety are fully discussed in the payload canister evaluation section of the SAR for the shipping cask.[18]

Designs of these three types of canisters were essentially completed in 1985. These designs were the keys that supported final development of the defueling equipment and allowed integration of the other parts of the overall core debris handling systems. With canisters and contents well defined, the shipping cask could be selected and the INEL storage equipment could be specified.

2.3.3 Canister Related Issues. Approval of GPU Nuclear's canister designs by DOE was granted only after a thorough safety review of the designs by EG&G Idaho. There were several aspects of the canisters' designs that DOE and EG&G Idaho did not favor, but were able to accommodate. The principal concern was with the use of fixed poisons inside the canisters, which could not be periodically inspected to ensure continuing satisfactory performance. Also, the INEL has a long-standing policy for containers, such as the core debris canisters, requiring threaded connectors to also be welded to prevent leakage past the threads during storage. Use of a pipe-joint compound at the INEL was typically not allowed because of the likelihood of deterioration from high radiation fields and the potential for subsequent leakage. The designs of canisters made it nearly impossible to weld the threaded connectors. GPU Nuclear was able to locate a pipe-joint compound that could withstand the expected radiation fields, and DOE allowed the material to be used.

DOE also had to approve changes to the canister designs and one was required just after the start of defueling, prior to the first shipment. The original fuel canister design used a metal gasket seal between the removable upper head and the bulkhead on the canister body. The seal was able to pass the pneumatic pressure test of 150 psi as required for an American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code stamped pressure vessel. However, in use for defueling, the metal seal was found to leak too easily during remote installation of the heads to the bodies. The seal material was changed to an elastomer, which required that the canister specification and drawing be changed. DOE approved the new material and verified that the head bolt torque limit of 90 ft-lb imposed by the INEL would not be exceeded.

Canister design was not the only safety concern of DOE. Fabrication of canisters in accordance with the approved design specification also required DOE oversight. One fabrication-related issue was surface rust observed on the lower head of an unassembled canister during a first–article inspection by an EG&G Idaho quality engineer at one of the canister vendors. Since the canisters were constructed of Type 304L stainless steel, which is resistant to rust and corrosion, this was of particular concern to the INEL for long-term storage. EG&G Idaho and GPU Nuclear investigated this issue and concluded that the rust was residue die material that became imbedded in the stainless steel head during the forming operation. The carbon steel from the die that stamped out the reverse dish lower head became oxidized during subsequent heat treatment, forming a rust deposit. As a result of this observation, the procedure for forming the heads was changed to eliminate the possibility of contaminating the stainless steel.

A second fabrication issue involved the rules of Section VIII of the ASME B&PV Code, which require traceability of materials throughout the manufacturing process and after placement into the pressure boundary of a code-stamped pressure vessel. During a first-article inspection by an EG&G Idaho quality engineer at one of the canister vendors, the specific heat number of the material was found to have been stamped on the inside of the canister's head, which was then welded to the canister body, preventing the inspector from reverifying the heat number. This issue was corrected by requiring that the vendors permanently mark each pressure boundary component of a canister with the material heat numbers in a location that was visible after the fabrication was completed. EG&G Idaho verified that these numbers existed for each canister as part of the source inspection performed for each canister.

Another issue arose just after the start of defueling with the use of fuel type canisters. GPU Nuclear tracked a canister by the body number, which is etched on the bulkhead, while EG&G Idaho tracked a canister by the head number. Since the fuel canisters were ASME-code-stamped pressure vessels pressure tested with a "matching" head and body (same number), EG&G Idaho was concerned that interchanging heads would possibly negate the code stamp and also complicate recordkeeping of the fabrication, documentation, and identification of canisters. GPU Nuclear determined that interchanging the heads did not negate the code stamp and committed to limiting the interchanging of heads and bodies to emergencies only.

Also, GPU Nuclear was experiencing problems with the premature plugging of filter canisters from microorganisms and fine core materials. Agreement had to be reached for use of a biocide, a hydrogen peroxide solution, a diatomaceous earth body feed, and a coagulant to enhance performance of the filters. Use of the biocide, body feed, and coagulant had to be reviewed and approved by DOE for both transportation and long-term storage at the INEL. The Transportation Certification Branch (TCB) of NRC also had to review and approve the potential impact of these materials on the safety of the shipments. As part of the review, the effect of adding the body feed, coagulant, and biocide into the catalyst recombiners of canisters had to be evaluated.

2.4 Logistical Studies

Logistics, as used in this report, refers to the evaluation of various approaches for handling and transporting shipping casks. Truck versus rail shipments and wet versus dry loading were the principal alternatives evaluated before procuring the casks. For each alternative, the associated costs and schedules were determined for the number of shipments necessary to move the complete core to the INEL. A shipment or shipping cycle consisted of these major steps: (a) preparing a loaded canister for transport, (b) loading prepared canisters into a shipping cask, (c) preparing a loaded cask for transport, (d) loaded-cask transport operations, (e) unloading a cask at the

INEL, (f) preparing an empty cask for return to TMI-2, and (g) empty-cask transport operations. Logistical studies estimated the time required and the costs for each step and considered the interdependencies between activities performed at TMI-2 and the INEL during a cycle.

Cask procurement decisions were based on results of the logistical studies. The major cost elements were a significant function of the type of cask and transport mode selected (i.e., truck or rail shipment). The cost for the casks, the associated transport costs, and the loading and unloading costs were all determined based on the type of cask selected. Minimization of total project costs for the transport campaign required evaluation of costs for several logistical alternatives to determine the lowest cost approach.

2.4.1 Truck Transport Alternative. Studies in 1981 on cask systems for transport of the TMI-2 core debris focused on potential use of existing spent fuel shipping cask designs.[4] In October 1982, a GPU Nuclear planning study recommended that legal-weight-truck (LWT) casks be used to transport the TMI-2 core debris.[19] The two major factors were the weight of rail casks exceeded 70 tons and could not be handled for underwater loading in the TMI-2 spent fuel pool, and the costs associated with rail cask use were estimated to be too high. Another problem was that space in the TMI-2 Fuel Handling Building's spent fuel pool was not available for a rail cask because equipment (the submerged demineralizer system) had been installed for cleanup operations.[20]

The GPU Nuclear study identified the NLI 1/2 LWT cask as the most appropriate existing design for the core debris shipments. The cavity of the NLI 1/2 LWT was large enough to accept a full-size canister [considered at that time as approximately 33.973 cm (13.375 in.) outside diameter and 431.8 cm (170 in.) long]. This canister size was based on an ability to accept an intact, full-length fuel assembly of the design used in the TMI-2 core.

In March 1983, EG&G Idaho identified eight shipping casks (both truck and rail) that were potential candidates for the shipping program. GPU Nuclear was requested to eliminate those casks that should not be considered for lease negotiations and to further provide an estimate of the rate at which shipments could be made from TMI-2. GPU Nuclear organizations with responsibilities for spent fuel shipping reviewed the list of casks and identified that only three LWT casks should be considered.

In April 1983, based on an assumed sequence of operations expected for loading an NLI 1/2 LWT cask, GPU Nuclear determined that receiving an empty cask, loading one canister, and preparing a loaded cask for transport would require seven to eight shifts over five to seven working days. At the INEL, one canister per week could easily be received and unloaded. However, at this rate for a total of 238 canisters, the campaign was projected to require more than four years to complete.

In May 1983, based on GPU Nuclear's evaluation of their ability to handle and load existing LWT cask designs, EG&G Idaho recommended to DOE to proceed with procurement of LWT casks. EG&G Idaho received DOE authorization to proceed in June 1983 and started preparing the request for proposals (RFP). An important consideration in the scope of supply was defining the interfaces between TMI-2 core debris canisters and the cask. These included canister length, diameter, weight, and radioactive material content.

Also in June 1983, a meeting was held with the TCB of NRC to discuss the issues to be addressed in approval of shipments for the TMI-2 core debris. The meeting identified NRC's position that the TMI-2 core debris would be treated as a plutonium shipment requiring double containment per Title 10 of the Code of Federal Regulations (CFR), Part 71.63 and not as spent fuel assemblies. Following that meeting, planning proceeded on the basis that to comply with the double containment requirement, one level of containment during transport would be provided by a shipping cask and the other by a canister.

In August 1983, EG&G Idaho issued the RFP for lease or purchase of LWT casks. Offerors were to propose prices for delivery of four to ten casks starting with a delivery date of January 1985 (corresponding to the GPU Nuclear expected date for start of defueling). A canister was to serve as one level of containment during transport. The RFP was further based on underwater (wet) loading of a canister into the cask at the cask loading station in the TMI-2 spent fuel pool.

Three addendums were issued for this RFP. The addendums transmitted answers to questions discussed at the preproposal conference and revised cask delivery schedules because of changing schedules for the start of defueling operations. Six proposals were received in response to this RFP, of which two were considered technically acceptable. However, during the several months of the procurement process and before a contract was awarded, new factors entered into the considerations for cask procurement and necessitated a delay in the award of a contract.

One factor was determining how many casks could efficiently be used. After review of GPU Nuclear's April 1983 estimate of a shipping rate of one canister per week, EG&G Idaho requested further study to improve cask turnaround time at TMI-2. In July 1983, EG&G Idaho funded a study by GPU Nuclear to review planned cask loading operations at TMI-2 with an objective of increasing the LWT cask shipments to five canisters per week. DOE was interested in evaluating options that would allow completion of the shipping campaign within the shortest, economically feasible timeframe.

GPU Nuclear's scoping study for core debris shipping planning consisted of two phases. The first phase was just to identify facility or program modifications that would be needed to reach a rate of five canisters shipped per week. The second phase was to provide detailed cost estimates and implement selected modifications.

In September 1983, three options were suggested by GPU Nuclear as having the greatest potential for improving cask handling and reducing turnaround time. These were as follows:

- Design and build a truck cask handling facility with two truck bays and an equipment laydown area as an alternative to using the existing Fuel Handling Building truck bay. This facility would be used for (a) receipt inspection of incoming empty casks, (b) health physics surveys, (c) removal of personnel barriers and impact limiters from the cask body, (d) protected temporary storage for cask equipment laydown, (e) reassembly of a loaded cask, and (f) preshipment inspections. This approach would still have allowed wet loading of a cask underwater in the spent fuel pool. However, time would be saved by performing other cask handling steps out of the truck bay, which is used for other TMI-2 waste shipments and incoming TMI Unit 1 (TMI-1) new fuel shipments.

- Design and fabricate an intermediate fuel handling cask that would transfer a loaded core debris canister from the spent fuel pool to a shipping cask. This approach was known as "dry loading" of a shipping cask since the shipping cask was loaded without being submerged in the spent fuel pool. Instead of taking the cask into the pool to be loaded with a core debris canister, a canister was taken inside of a shielded fuel handling cask to a shipping cask located in the truck bay. The time-saving advantages of this approach were substantial since cask washdown, hands-on decontamination, and cavity draining were eliminated. In addition, the lighter weight of a "transfer" cask, in comparison to a shipping cask, eliminated concerns with dropping a shipping cask in the spent fuel pool and substantially reduced concerns for drop of a heavy load in the pool.

- Increase shift coverage to three shifts per day, which would also reduce the number of days to turnaround a single cask in comparison to GPU Nuclear's original estimate of five to seven days.

In addition to trying to determine a faster turnaround time for GPU Nuclear, another factor in delaying truck cask procurement was the uncertainty as to whether a canister should be required to provide a level of containment during transport. In November 1983, SNL TTC completed an assessment of double containment during transport and concluded that "leaktight" leakage rate seals would be required for the inner-most level of containment. Per American National Standards Institute (ANSI) N14.5, leaktight is a leakage rate of 10^{-7} atm-cm^3/sec (10^{-8} Pa-m^3/sec) or less (e.g., a volume of gas less than the size of a golf ball released in a year).[21]

Per the ANSI N14.5 standard, a maximum allowable leakage rate for a level of containment for a packaging was determined based on the 10 CFR 71 limits for releases of radioactive materials during normal and hypothetical accident conditions. When the normal condition limit for plutonium (curies per second) per 10 CFR 71.63(b) was divided by an estimate of the curies per unit volume in a canister, the resulting maximum allowable leakage rate was less than the "leaktight" criterion. In this case, the leaktight limit applied to the hardware designed to be the inner-most level of containment of a plutonium packaging. For the TMI-2 shipments, the inner-most level was the canisters. Because of the design of the canisters, with several penetrations for loading and dewatering, costs for applying the leaktight criterion to each canister with its multiple seals needed to be considered in comparison to the cost-effectiveness of having the cask provide both levels of containment.

By December 1983, more factors were being identified as having a bearing on selection of the type of cask to use in the shipping campaign. In that month, EG&G Idaho initiated a study by GENCON, Inc., and MPR Associates, Inc., to evaluate the possible alternative of using government-owned rail casks to transport the TMI-2 core debris. This study was initiated due to three developments around that time:

- The Phase I handling studies performed by GPU Nuclear on truck casks showed that the use of a dry-loading method rather than a wet-loading method would reduce cask loading turnaround times at TMI-2. The dry loading approach also reopened the possibility that loading rail casks in the truck bay in the Fuel Handling Building would be a viable alternative and should be considered as opposed to proceeding with the procurement of truck casks.

- The sonar mapping of the core's topography was completed and indicated that few full-length fuel assemblies were left standing in the TMI-2 reactor vessel. This opened the possibility that the damaged fuel could be shipped in shorter-length canisters, rather than full-length canisters, 431.8 cm (170 in.) long. The possible use of canisters only 330.2 cm (130 in.) long provided an opportunity to evaluate improvements in shipping economics and logistics through the use of government-owned rail casks, which had an inside cavity length of 330.2 cm (130 in.).

- DOE had begun to ship spent fuel assemblies from the Shippingport Light Water Breeder Reactor to Idaho in three existing government-owned M-130 rail casks. Modifications to the cask to accept Shippingport fuel assemblies had already been made, accepted by NRC, and appeared to be comparable to the changes that would be needed for shipment of TMI-2 canisters. The M-130 casks were dry-loaded at Shippingport, which provided a working example of the approach being considered at TMI-2.

Potential use of the M-130 casks for the TMI-2 core debris shipping campaign prompted comparison of costs and schedules for rail versus truck casks. Part of the logistical evaluations were studies by both GPU Nuclear and the INEL on handling rail casks at the same rate as truck casks, an average of five canisters per week. The scope of GPU Nuclear's Phase II study was broadened to include the M-130 rail cask in particular and rail casks in general. The INEL similarly considered both truck and rail casks to determine if cost and schedule advantages were available from using rail casks.

The studies by GENCON/MPR, GPU Nuclear, and the INEL were completed in March 1984 and formed the basis of an EG&G Idaho recommendation that DOE's TMI-2 Program Office contact the DOE Naval Reactors Program about the possible loan of government-owned M-130 shipping casks for the TMI-2 core debris campaign. The studies showed that a savings to the DOE program estimated at seven million dollars would result in comparison to previously planned truck cask shipments. GPU Nuclear would also save millions of dollars from lower cask loading costs.

In April 1984, the Naval Reactors Program responded that M-130 casks could not be made available in the timeframe needed for the TMI-2 schedule because of other commitments. Although those particular rail casks were not available, the results of the studies changed the direction of the cask procurement. The studies showed that GPU Nuclear loading costs and INEL unloading costs would be substantially less for rail casks compared to truck casks and, therefore, the advisability of soliciting bids from commercial suppliers for suitable rail casks that could be dry loaded in the TMI-2 truck bay. In May 1984, the original RFP for truck casks was canceled in favor of a broader RFP for rail or truck casks.

2.4.2 Rail Cask Procurement. By April 1984, commercial cask suppliers had learned of the studies showing advantages to the use of rail casks. DOE-HQ received two letters from Nuclear Assurance Company (NAC) regarding the availability of commercial casks, including an informal offer to provide casks and transport services for a firm-fixed price. That offer was subsequently withdrawn. In the same month, DOE concurred with EG&G Idaho's determination of the advisability of pursuing a broader scope RFP for commercial supply of rail or truck casks. A new RFP was prepared to ensure that the then current and applicable shipping cask technical requirements would be identified to all prospective suppliers and that competition would result in the most advantageous, lowest-price, responsible offer.

As noted above, the new RFP was prompted both by GPU Nuclear and INEL cask handling studies and the unavailability of the M-130 casks, but there was also a major change in canister design requirements. GPU Nuclear had been working on both defueling equipment and canister designs and arrived at the three types of designs described previously in Section 2.3.2. As the potential impacts of having the canister provide a level of containment during transport became apparent, GPU Nuclear reconsidered having to meet the transport-related requirement and requested that the cask provide both levels of containment. GPU Nuclear determined that the canisters were crucial to the start of defueling the reactor and might not be easily nor expeditiously designed and certified to meet the strict leaktight leakage requirements of a level of containment during transport.

EG&G Idaho considered GPU Nuclear's request in preparing a new RFP for cask supply. Proposals for the casks were to offer an optional separate inner containment vessel that would meet the requirements for double containment in 10 CFR 71.63 and have leaktight leakage rate seals. Prices for this option allowed EG&G Idaho to evaluate the cost-effectiveness of having the cask, as opposed to the canisters, meet the double containment with leaktight seals requirement.

The new RFP was issued in May 1984 and superseded the original RFP for cask supply. The new RFP requested proposals on lease or purchase of LWT casks and/or rail casks with an option for a separate inner containment vessel in each cask. The RFP also requested proposals for maintenance and transportation management services per a request by NAC to DOE-HQ in April 1984. The proposal due date was

June 11, 1984. A preproposal conference was held in Washington, D.C., on May 18, 1984, to explain the new requirements and answer any questions relative to the new RFP.

The scope of supply requested in the RFP included from eight to ten truck casks or two to four rail casks. Delivery was requested by June 1, 1986, for the first unit with final delivery before March 15, 1987. The dry loading approach was identified as the means to load canisters into the cask, although the fuel transfer cask was not requested to be included in the scope of supply when this RFP was first issued.

The original six proposers to the first RFP, and one new prospective proposer, attended the preproposal conference. Addendum No. 1 to the RFP was issued on May 25, 1984, and transmitted the preproposal meeting notes; clarification of the scope of supply; and crane hook drawings of the TMI, INEL Central Facilities Area (CFA), and INEL Test Area North (TAN)-607 cranes. Clarification of the scope of supply in Addendum No. 1 included specifying those items required from the cask vendor (i.e., cask, lifting equipment, SAR, operations and maintenance manuals, spare parts, and containment seal test equipment) and those optional items that a vendor may also have proposed (separate inner containment vessel, cask loading stations for the TMI-2 truck bay and INEL Hot Shop, transfer cask for dry loading at TMI-2, and other specialized equipment as necessary).

A meeting was held at TMI-2 during the week of June 11, 1984, to evaluate the eight proposals received from seven companies (NAC, one of the proposers, submitted a second proposal as a combined proposal from National Lead, Inc., and NAC). Based on this proposal review meeting and lease cost evaluations, a decision was reached that purchase of rail casks as proposed by NuPac, of Federal Way, Washington, met all criteria for technical and cost acceptability.

In reaching a final decision, the proposals were evaluated in strict accordance with the RFP and avoidance of technical leveling as defined in the Federal Acquisition Regulations, Title 48 CFR, Part 15.610, Written and Oral Discussions; i.e., "the contracting officer and other Government personnel involved shall not engage in technical leveling (i.e., helping an offeror to bring its proposal up to the level of other proposals through successive rounds of discussion, ...)." EG&G Idaho Subcontracts and TMI Technical Integration Office (TIO) program personnel determined that discussions with the other proposers, all of which submitted unacceptable technical proposals, would not have resulted in an upgrade of their proposals to the point of being competitive with the NuPac proposal except through a process of technology transfer of the technical information in the NuPac proposal to the other proposers. Therefore, the proposals were evaluated as submitted.

An award of a Letter Subcontract to NuPac was made on August 7, 1984, followed by a definitive subcontract upon receipt of an audit report relative to NuPac's accounting system and pricing data. The price EG&G Idaho agreed to for two rail casks, two rail cars, auxiliary equipment, and an NRC Certificate of Compliance (CoC) to current regulations was $2,191,028. Final costs under this contract were eventually higher as a result of contract scope revisions due to changes in program requirements, as discussed in Section 2.5.2 and Appendix D.

A letter of protest was submitted August 10, 1984 (and amended August 23, 1984), by Tighe, Curhan, and Piliero, Attorneys at Law, on behalf of NAC, to the General Counsel of the U.S. General Accounting Office (GAO). The protest requested a delay in award of the contract for the TMI-2 shipping casks until after the protest was reviewed.

DOE's response to this protest included submittal of a substantial number of letters and other documents and a meeting at the GAO with the interested parties. The NAC protest culminated in a decision in January 1985 by the Comptroller General of the United States that the protest was dismissed in part and denied in part. A copy of the GAO's decision is provided as Appendix E.

During the six-month period the GAO reviewed the protest, progress was still able to continue in developing the cask system to transport the TMI-2 core debris. Since award had been made before the protest was filed, the GAO allowed work under the subcontract to proceed. However, the protest spawned a number of related investigations, which diluted the efforts of EG&G Idaho and DOE by diverting management and engineering personnel from the primary objective of shipping program development. The investigations eventually affirmed the validity of several DOE decisions.

For example, an extensive investigation was initiated by Senator John Heinz (deceased), of Pennsylvania, on DOE's actions related to cask procurement and the ability to meet DOE's previously announced target schedule for start of core debris shipments from Pennsylvania. This investigation involved then Secretary of Energy Donald P. Hodel, the Senate Hearings for incoming Secretary John S. Herrington, the Chairman of the Nuclear Regulatory Commission, the Comptroller General of the United States, the Office of the Inspector General-DOE, and others.

Technically, the award of the contract to NuPac established the means by which cask and canisters could be fully integrated into a transport package. The contract signed with NuPac on the proposed cask design included selection of the option for the cask to include a separate inner containment vessel with leaktight seals. This option was clearly less costly than requiring each canister type and every canister fabricated to meet the very strict leakage rate design and testing standards specified in ANSI N14.5 for compliance with 10 CFR 71.63 requirements.

The canisters were designed, manufactured, and stamped (approved) as pressure vessels meeting the ASME B&PV Code. The canisters were also notably more rugged than the containers normally used to ship failed fuel assemblies (leakers). However, the TMI-2 canisters were also process vessels with penetrations not especially well-suited to being leaktight seals. In particular, the fuel canister design with its removable upper head was designed with face seals around the square opening of the canister's cavity and around the drain line.

Although canisters were thoroughly sealed for all other TMI-2 and INEL site handling requirements, the seal configurations as designed would likely have had leakage rates higher than the leaktight standard required for transport of plutonium and difficulties in testing the leakage rates for each seal. Changing the design to readily meet transport requirements would have delayed GPU Nuclear's progress toward the start of defueling operations.

Even though the designs of the canisters did not have to undergo a determination by the NRC TCB as meeting the requirements for a level of containment during transport, each canister was a confinement vessel during transport. In fact, substantial credit was taken for being a confinement vessel in evaluating the safety of the cask in the criticality analyses, since core debris was not modeled outside of canisters in the cask. Except for not "proving" the canister seals were leaktight per the ANSI N14.5 standard requirements and therefore qualified to be a containment boundary, the canisters were an additional and substantial boundary preventing the release of core debris materials during transport.

2.5 NuPac 125-B Rail Cask

Development of the rail casks and associated equipment by NuPac for the TMI-2 core debris shipments became a project with many interrelated aspects. The project involved cask design, contract modifications as the support needed from NuPac changed, licensing of the cask by the NRC TCB, drop tests of a scale-model cask, support for drop tests of a full-scale knockout canister, cask fabrication, and supply of heavy-duty railcars and auxiliary cask handling equipment.

2.5.1 Cask Design. The cask design proposed by NuPac for the TMI-2 core debris shipments was designated the Model 125-B cask and assigned NRC licensing docket number 71-9200. Known as the NuPac 125-B cask, or the 125-B cask, the design included features specifically intended to meet the special requirements for double containment of plutonium.

As shown in Figure 2-5, the cask contained seven TMI-2 core debris canisters in a separate inner containment vessel (ICV) placed within the 127-cm (50-in.) diameter cavity of the outer cask body, or outer containment vessel (OCV). The ICV lid was provided with two O-rings in a bore seal design with a leaktight leakage rate. Each canister was located below a shield plug in the ICV that reduced radiation dose rates to workers testing the seals on the ICV lid. Upper and lower impact limiters were provided to protect each canister in the event of a vertical drop of the cask onto either lid or bottom end. The internal impact limiters would have helped reduce the deceleration loads experienced by a canister in accident conditions to less than the design basis for the canister's criticality control structures. Similarly, the ICV structure incorporated stainless steel plates between stainless steel tubes to support the canisters in the event of a drop onto the side of a cask during transport. The spaces outside of the tubes in the ICV were filled with neutron absorbing materials for criticality control of the array of seven canisters.

The OCV provided the primary containment and environmental barrier. The OCV consisted of a conventional stainless steel and lead cask body with forged stainless steel lid and bottom plate. The body was surrounded circumferentially by a stainless steel fire shield. Steel shells containing polyurethane foam, called overpacks, were attached to each end of the OCV to protect the cask during normal and accident conditions of transport. The cask design was passively cooled since the maximum decay heat of a canister was only 100 W (or 700 W for a fully loaded cask).

The cask design offered in NuPac's proposal required a dimensional change soon after the contract was awarded. Reflecting the dynamics of the cask and canister systems integration problem, the canister's length had changed from the original 432 cm (170 in.) for a full-length fuel assembly to 330 cm (130 in.) when the M-130 rail cask was under consideration. After receipt of the rail cask proposals in June 1984, canister length was increased to 381 cm (150 in.), which was the minimum length specified for any proposed rail cask.

Whereas the changes in canister length were accommodated by GPU Nuclear without considerable impact to canister handling system designs, a canister diameter change was requested by GPU Nuclear that had noticeable effects on the cask. The canister's diameter had been specified by GPU Nuclear for use by EG&G Idaho in the RFP for the cask supply. However, by the time the cask contract was awarded, the canister design process determined that an increase in the outer diameter from 33.7 to 35.6 cm (13.25 to 14 in.) was necessary.

GPU Nuclear's proposed canister diameter increase considered the following factors. The boral-plate shroud assembly for the fuel canister design would be an off-the-shelf-design item for a 35.6-cm- (14-in.-) diameter canister, but would need to have been redesigned for a smaller diameter canister. A shroud for a 35.6-cm- (14-in.-) diameter canister would have a relatively larger cross-sectional area than for the smaller diameter canister and would make loading of damaged fuel assemblies an easier task. Larger diameter canisters would have a larger volume per canister for loading fuel and would require fewer canisters to load the entire core. A larger outer diameter was needed for the hydraulic performance of the knockout canisters since smaller diameter canisters would have had increased internal flow velocities.

The technical bases for the small increase in outer diameter from 33.7 cm (13.25 in.) (May 1984) to 35.6 cm (14 in.) (August 1984) were sufficient for EG&G Idaho to change the canister interface requirements specified in the cask supply contract. The small increase in canister diameter caused a corresponding radial increase in diameter for each of the canister cavities in the ICV. The inner and outer diameters of the ICV and the OCV were then also forced to increase. The net effect was a slightly larger and heavier cask than originally proposed and a change in cask contract price to accommodate the revised canister diameter.

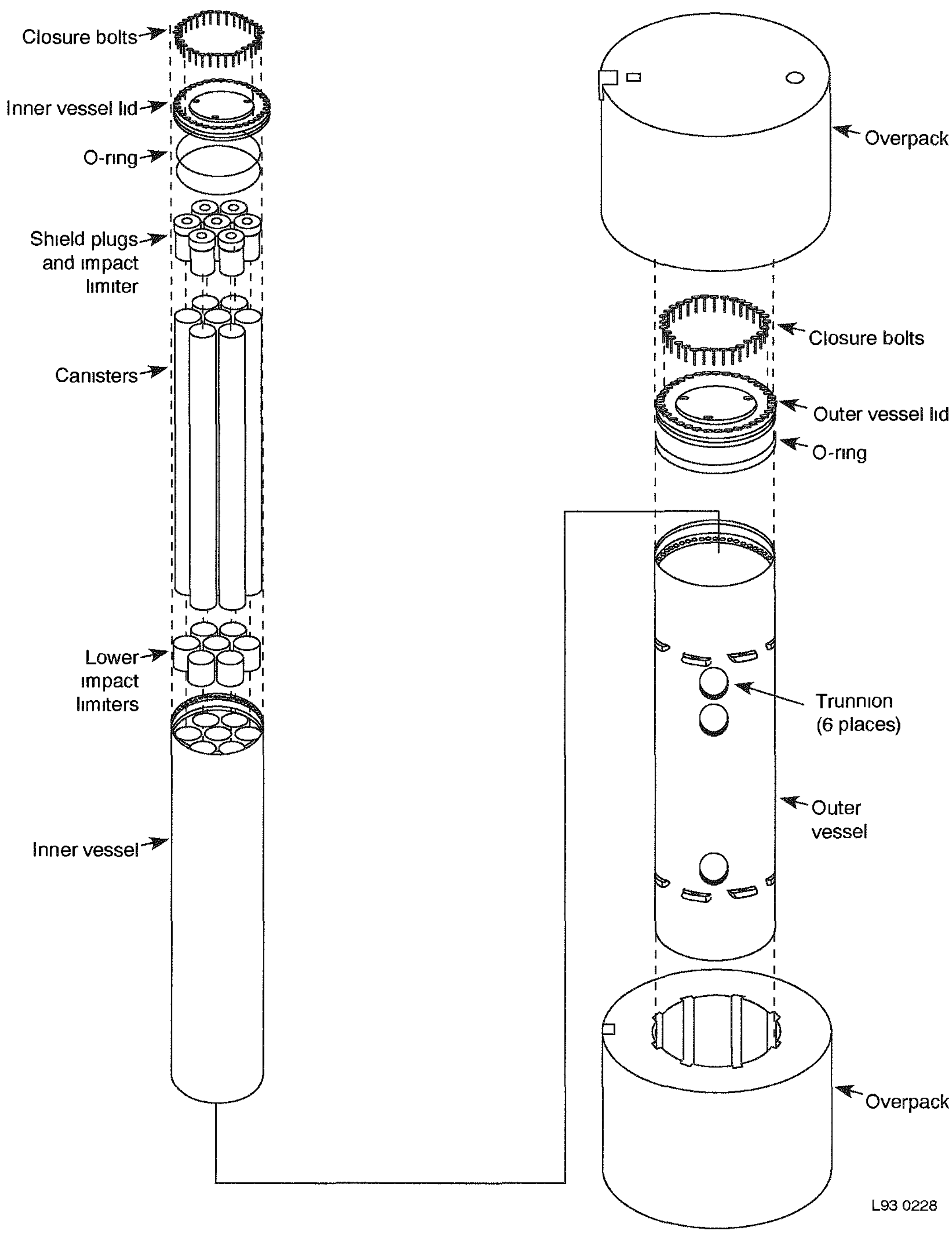

Figure 2-5. Exploded view of the NuPac 125-B rail cask.

As shown in Figure 2-6, the cask system final design was 7.1 m (23 ft 3.5 in.) long, including the overpacks. The total weight of the loaded cask with overpacks and seven fully loaded canisters (2,940 lb each) was about 181,500 lb. The gross weight on the railcar, including the transport skid, which mounted on the railcar and supported the cask in transit, was about 203,000 lb. The total weight on the rails, including railcar, was about 310,000 lb.

2.5.2 Contract Modifications. The scope of supply initially awarded to NuPac was changed several times due to new or revised programmatic requirements. A summary of the contract modifications and prices is presented in Appendix D. The original scope included the following items:

- Two OCVs with overpacks
- Two ICVs
- Two shipping skids
- Two railcars
- One vertical lift fixture
- One NRC CoC.

Before the end of the contract, the following changes were made to the scope of supply:

- Perform of a drop test program for a one-quarter scale cask model
- Supply one lifting yoke
- Supply one horizontal lift frame
- Supply two plastic scale models
- Increase the load carrying capacity of the two railcars
- Travel to NRC and Core Shipping Technical Working Team meetings
- Incentive for early delivery of the casks
- Accommodate a change in canister diameter
- Delete licensing fee not paid to NRC
- Accommodate a change to the structural design of the knockout canister
- Clarify the delivery date under the incentive clause
- Provide technical support for a canister drop test program
- Accommodate a change in criticality analysis for filter canisters
- Supply special cask handling equipment for use at TMI-2
- Revise the delivery date for the incentive clause
- Supply a pressure-rise leakage rate test system
- Revise design of cask handling equipment
- Supply canister test weights for an integrated test of cask and handling equipment
- Support resolution of a fabrication-related quality assurance (QA) audit finding
- Perform a seal leakage rate test at TMI-2.

As discussed in Section 3.4.1, NuPac continued to provide assistance to the TMI-2 core debris shipping campaign under subsequent contracts for technical support to maintain the NuPac 125-B cask license current and to assist with changes to the payload requested by GPU Nuclear.

2.5.3 Cask Licensing. Cask licensing centers around demonstrating that a shipping package meets Federal safety requirements for transport during both the normal and hypothetical accident conditions of transport. This involves submitting an application that consists of an SAR for the shipping package and defending the analyses during review by the regulatory authority. A shipping package is the combination of the packaging (outer container for the radioactive materials) and the radioactive contents.[22]

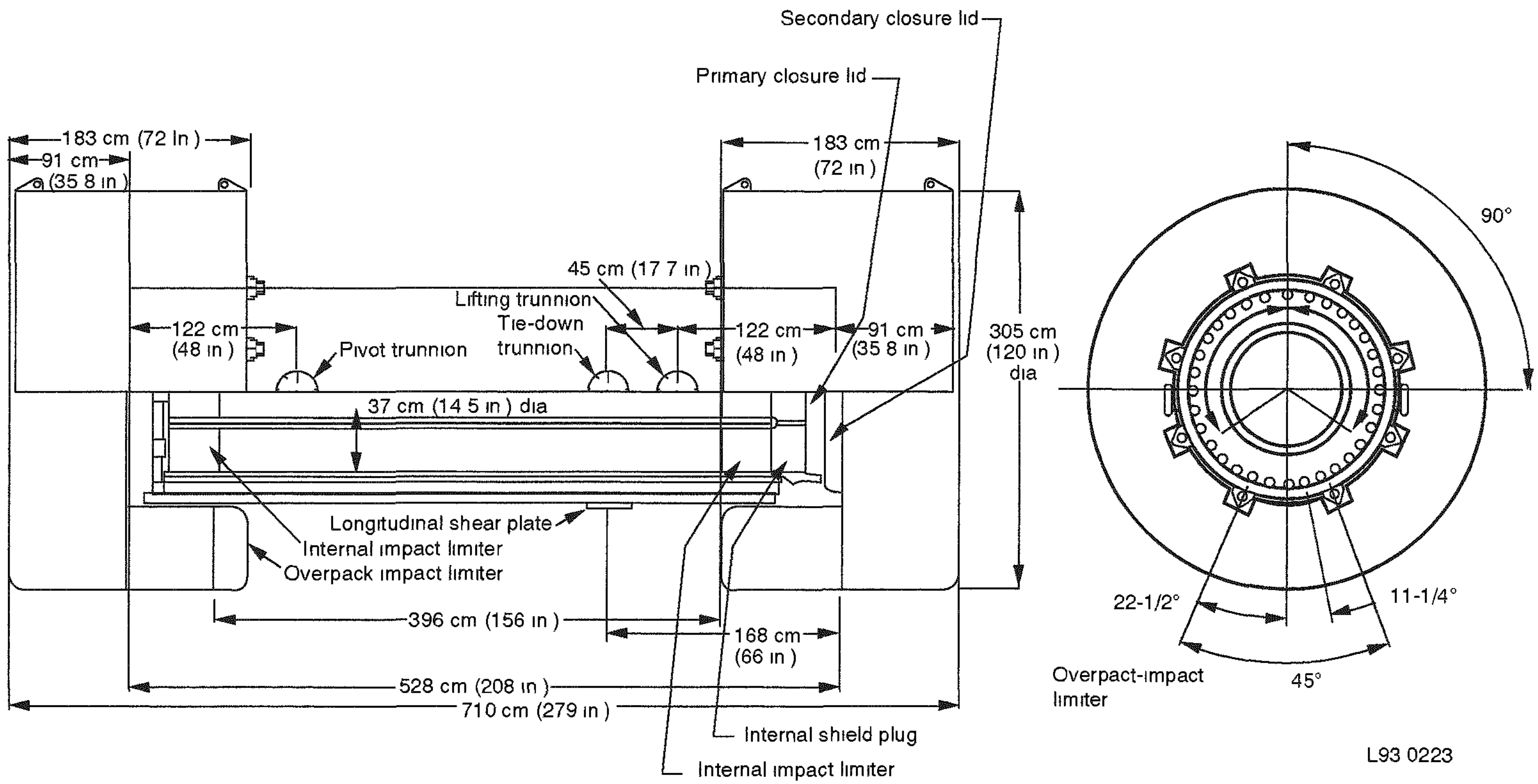

Figure 2-6. Overall arrangement of NuPac 125-B rail cask.

When the radioactive material to be packaged is new or unique, such as the TMI-2 core debris, a new package design can be developed specific to the material, or an applicant can choose to show that an existing packaging design would be acceptable for the material, perhaps with modifications to the existing design. For a new package design, an SAR is submitted for certification, while for a revision to an existing packaging design, the SAR is revised to reflect the changes and is resubmitted to the regulatory authority for approval of the new contents.

Prior to either an initial application or a revision to an existing SAR, discussions may be held with the regulators to inform them of development of, or changes to, a package and to obtain guidance for areas of concern that would need to be addressed for approval of a specific package application. For the TMI-2 core debris shipments, many discussions were required with the regulators before submittal of the 125-B cask SAR.

The first meeting with the NRC TCB on the TMI-2 core debris shipments was held on June 27, 1983. As noted in Section 2.4.1, the meeting was an introduction to the technical issues that would be specific to transport of the TMI-2 core debris. The meeting included discussions on GPU Nuclear's review of candidate casks for the shipping program (existing designs, modifications to existing designs, and new designs), a presentation on the canister design as of that date, and information on the expected condition of the core debris. NRC identified a perceived need for double containment during transport. For GPU Nuclear, the meeting confirmed expectations that existing spent fuel casks were viable candidates for the TMI-2 core debris shipments and that the canisters would provide a level of containment during transport.

Although GPU Nuclear requested the 1983 meeting with NRC, an EG&G Idaho representative attended and identified that DOE was expected to be the shipper under the terms of the soon-to-be-signed core contract. DOE has authority under U.S. Department of Transportation (DOT) regulations to self-certify radioactive material shipping packages.[23] NRC asked whether DOE would be its own regulatory authority and use a self-certified package or if DOE would elect to use an NRC-certified package.

DOE chose NRC to be the regulator for approval of the TMI-2 shipping casks based in part on the initial planning that had indicated that an already existing NRC-certified truck cask would be the least-cost alternative for the transport program. Another reason for this choice was the fact that TMI-2 was a commercial reactor site regulated by NRC and activities performed by GPU Nuclear, such as canister and cask preparations for shipment, were under the regulatory review of NRC. Also, there was a concern regarding the public's perception of DOE's self-certification process at that time and a potential for claims by the public that the cask would not be safe if self-certified by DOE.[d]

After award of the contract for supply of the two NuPac 125-B casks, licensing efforts with the NRC were initiated in earnest with the first of many information presentation and exchange meetings. The purpose of these early meetings were exploratory, directed at soliciting NRC views or opinions on the proposed approaches for resolving licensing issues in the cask and canister design and fabrication processes; what the NRC viewed as acceptable versus possibly unacceptable; and other issues. Early discussions were closely coupled to GPU Nuclear's canister design and the envelope of issues for preparing the core debris at the TMI-2 site.

The earliest meeting on licensing of the NuPac 125-B cask was held on August 29, 1984. The meeting included only NRC, NuPac, and EG&G Idaho representatives. NuPac presented the basic design assumptions to be used in developing the cask's inner and outer containment vessels. NRC supported the general approach for

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d. In January 1986, DOE moved to strengthen its self-certification process by removing authority from the individual DOE field offices and requiring approval of all shipping package designs by a centralized certification office independent of any programmatic activities.

double containment and leaktight leakage rate seals on both vessels. However, NRC expressed concerns regarding the limited information presented at the meeting regarding the canisters and their TMI-2 core debris payload. In particular, NRC was interested in deformation of structures in canisters that provide criticality control during hypothetical accident conditions of transport, pressure relief due to residual water content in canisters, and radiolytic gas control in canisters.

The proposed schedules for development of the cask design were also reviewed with NRC. Both the originally proposed schedule and a schedule based on an incentive for early delivery of the cask to EG&G Idaho appeared reasonable to NRC since almost six months were allowed for NRC's review of the application and subsequent revisions. At this meeting, the desirability of performing a scale-model drop test program for the cask and canisters was identified as an enhancement to the analytically based SAR. Scale-model testing of the package was viewed as a methodology to potentially verify the analysis of the cask's design.

A summary of this meeting was prepared by NRC TCB and placed into NRC's file under Docket Number 71-9200. Each subsequent meeting was similarly documented. The docket file also contains a copy of the application, all revisions to the SAR, and correspondence from and to NRC on this cask.

Following the initial NRC meeting, EG&G Idaho advised GPU Nuclear of the questions raised by NRC concerning the canisters. A meeting was held on September 26, 1984, with representatives from NRC TCB, NRC TMI-2 site office, DOE TMI-2 site office, EG&G Idaho, NuPac, GPU Nuclear, Bechtel, and B&W. The principal discussion centered on demonstrating that neutron poison structures in canisters would remain effective following a 9-m (30-ft) drop in a cask. B&W explained the results of 4.6- and 9-m (15- and 30-ft) drop tests performed on the fuel canisters without the protection of a cask (bare canisters dropped onto a flat reinforced concrete pad with a steel plate surface). While the adequacy of the fuel canister's criticality control structures were confirmed by the drop testing, the adequacy of these structures for knockout and filter canisters was expected to be demonstrated by analysis of the ability of the structures in the canisters to survive drop accidents.

An outcome of the two earliest meetings with NRC was a recommendation by EG&G Idaho to DOE to support NuPac's opinion that NRC wanted to see a one-quarter-scale model cask drop test program. The cask drop test program was not viewed as technically required to license the casks but rather as valuable to provide (a) verification of design and analysis assumptions, (b) an understandable demonstration of the safety of the cask design for the public, and (c) information to support an accelerated review of the cask certification application (i.e., the cask's SAR). Accordingly, the next two meetings with NRC were largely devoted to exploring and defining what scale-model testing would be of most value.

Meetings were held with NRC on November 29 and December 6, 1984, to discuss the cask's structural design in more detail and to obtain agreement from NRC on proposed plans for a one-quarter-scale cask drop test program. In addition to representatives from the NRC TCB, NuPac, and EG&G Idaho, a member of SNL TTC staff attended to develop an understanding of the objectives of the scale-model testing (which was later performed at SNL's facilities).

At the meetings, discussions on NRC's concerns with the cask's structural design included consideration of the stresses and strains to cause buckling of the inner shell of the cask's outer vessel during fabrication processes (during lead pour), buckling during both hot and cold drop accident conditions, and the strength of lid closure bolts. Discussions of the scale-model drop testing program centered on identifying those tests that could be of most value in the cask certification process. Multiple tests were determined to be necessary to demonstrate the safety of the cask in worst-case accident conditions. Because of the impracticality of fabricating scale models of the internals of the canisters, weights simulating the outer shape and mass of the seven canisters were proposed for the scale-model cask drop test program.

The inability to fabricate scale models of the canisters for the cask drop test program and minor changes made to canister designs since the September 1984 meeting with the NRC TCB on canisters prompted a January 16, 1985, meeting with NRC to present the latest information on design and evaluation of the three types of canisters. Representatives were present from NRC TCB, NuPac, EG&G Idaho, GPU Nuclear, Bechtel, B&W, and SNL TTC. A general description of the behavior of each type of canister was followed by detailed discussions of the mechanical features of the canisters' internals and the analytical and test approaches to demonstrating acceptable performance of the criticality control materials in transportation-related drop accidents.

The fuel canister design was only briefly discussed since a rigorous full-scale drop test program had shown the boral-plate shroud assembly sufficiently rugged. The discussion of the criticality control structures in the knockout canister design concluded that while a drop test might help, analysis (rather than tests) could be adequate for the SAR if the structural behavior of the tubes containing the B_4C criticality poison pellets were carefully modeled and analyzed. The filter canister discussion identified an inability to demonstrate the maximum deflection for the poison rod after a drop accident, but also noted an overly conservative approach of assuming a filter canister was filled with fuel pellet size core debris. Particles larger than 850 μ were prevented from entering a filter canister by screens upstream of the filter canister's inlet (e.g., at the outlet of knockout canisters).

As is evident from the above descriptions of interactions with the NRC TCB from award of the contract to NuPac until early 1985, cask licensing was a broad area that required project activities to proceed down several parallel paths toward resolution. NuPac took the conceptual design of the cask in their proposal and performed the engineering analyses necessary to complete a preliminary and then final design. The safety analyses of this design were incorporated into a working draft of the chapters in the SAR. GPU Nuclear completed final design of the canisters and prepared analyses to demonstrate the safety and integrity of the canister components during handling accidents onsite and while in transport. SNL TTC prepared to perform the quarter-scale model cask tests that are discussed in Section 2.5.3.1. In another significant effort, RHO was evaluating the special hazards associated with the safe transport of the core debris. Section 2.5.3.2 describes the special hazards studies and, in particular, the recombiner catalyst testing program.

The first half of 1985 marked the completion of the cask licensing support efforts. In a March 22, 1985, meeting, NuPac presented the final details of the scale-model cask drop test program to the NRC TCB. As described below, the tests were successful and the March 1985 meeting was the last with NRC before submittal of the SAR for the cask on June 14, 1985. The SAR contained the proposed technical bases for demonstrating that the 125-B casks met NRC's performance requirements.[18] The SAR provided NRC with detailed design drawings, technical descriptions, analyses, and test results for the cask and canisters. Following submittal, NRC placed review of the 125-B cask application ahead of reviews of other packages already submitted, since NRC management was committed to expedite the cleanup of TMI-2. After a six-week review of the SAR, NRC TCB requested a meeting to discuss questions identified during their review.

At a July 26, 1985, meeting, NRC summarized the major issues found in the SAR and for which written questions would soon be issued by NRC. There were several representatives from NRC and NuPac and one representative each from EG&G Idaho, SNL TTC, and GPU Nuclear since the meeting principally was for NuPac's benefit to obtain NRC's concerns with the cask rather than the canisters. After NRC expressed concerns on the canisters and interest in a canister drop test program, a follow-up meeting was held on August 6, 1985, to specifically discuss canister issues.

Representatives from NRC TCB, NRC TMI-2 site office, NuPac, EG&G Idaho, GPU Nuclear, Bechtel, and B&W attended the follow-up canister meeting. The principal concern was demonstrating the adequacy of the neutron absorber structures in these designs following hypothetical accident conditions. Fundamentally, since the structures were not strong enough to survive the drop accident forces without the potential for some permanent bending, NRC could not accept the computer analyses that predicted the amounts of deformation. The deformed positions of the poison structures were part of the input for the criticality analyses for the array of seven canisters in the cask. Based on their earlier suggestion at the most recent meeting, NRC expected to hear about plans for drop testing of canisters. GPU Nuclear came prepared to explain why the existing analyses in the SAR on the canisters were adequate. The meeting ended without significant progress on either testing or analytical approaches to demonstrating canister acceptability for transport, but a meeting was scheduled for August 20, 1985, to resume discussions.

NRC issued written questions on the SAR on August 9, 1985. The questions reflected the concerns NRC had discussed in the two recent meetings. Evaluations in the SAR for the cask needed revisions, but there were no "showstoppers." The evaluations for the knockout and filter canister designs were deemed insufficient to conclude that structural performance of the poison rods would be as presented in the SAR.

At the August 20, 1985, meeting, instead of presenting a proposed plan for drop tests of the canisters, GPU Nuclear requested that NRC consider "dry" criticality analyses or administrative moderator controls for the shipping package. This approach was based on the logic that the neutron poison structures were *only* required if unborated water were to leak into the cask, inner vessel, and canisters. Such water inleakage is an assumption required by NRC's regulations for evaluation of criticality controls in fissile material shipping packages. The regulations also allowed a package's safety analyses to exclude the assumed water inleakage if the package incorporated special design features that ensured no single packaging error would permit water inleakage.[24]

GPU Nuclear's logic was that since the NuPac 125-B cask had two independent containment vessels each with leaktight seals, each vessel was dry loaded, and the containment boundary seals were separately leak tested, the unique design features of the cask would allow compliance with the regulations without a need for assuming water inleakage for criticality calculations. Using this approach, there would not be a need to consider the poison structures in the canisters for safety during transport since unflooded cask and canisters were safely subcritical without any poisons in a canister.

NRC would not support this approach and indicated that a request for an exception to the need to assume water inleakage ". . . would not be viewed lightly." On a more positive note, GPU Nuclear presented revised criticality analyses of the filter canister that removed overly conservative assumptions. The new analyses offered hope that filter canisters could be approved by NRC based in part on criticality analyses for small-particle-size fuel debris materials and with the least amount of credit for the position of the poison rod in each canister.

Following this meeting on canisters, GPU Nuclear determined that requesting an exception based on moderator controls for the cask would not be advisable. GPU Nuclear proceeded to plan for a drop test program for the knockout canister design and revision of the filter canister's criticality analysis. Based on NRC's written questions, NuPac was able to revise the SAR sections for the cask analytically without a need for additional drop tests of the quarter-scale cask model.

Following preparation of a plan for a knockout canister drop testing program, GPU Nuclear requested a meeting with NRC TCB to review the proposed tests prior to performing them. Representatives from NRC TCB, NRC TMI-2 site office, DOE-HQ, EG&G Idaho, NuPac, GPU Nuclear, Bechtel, and B&W attended the September 5, 1985, meeting. The tests and revised criticality analysis for filter canisters proposed by GPU Nuclear established the approach to approval of these two types of canisters. The knockout canister drop test program is described in Section 2.5.3.3.

The results of the knockout canister drop tests, revised filter canister criticality analysis, and revised cask analyses were incorporated into Revision 1 of the SAR and submitted to NRC on October 31, 1985. NRC's review of the revised information was completed seven weeks later with a request for still additional information. The level of effort by both NuPac and GPU Nuclear to respond to the questions did not require any additional cask or canister drop testing. Canister-related concerns were resolved without a need for any additional meetings between GPU Nuclear and NRC TCB.

NuPac requested a meeting with NRC to review responses to NRC's concerns before submittal of Revision 2 of the SAR. A meeting was held on January 17, 1986, to ensure that NuPac correctly understood the questions and to determine if NuPac's answers were sufficiently clear. The meeting was worthwhile in establishing that draft responses presented at the meeting were not adequate. Issues included the adequacy of the inner vessel's lid bolts, analysis of the secondary impact for an oblique angle impact, chemical analysis of the cask's neutron poison materials, and other items from NRC's second set of written questions.

A follow-up meeting was held a week later on January 24, 1986. NuPac presented an approach that adequately responded to NRC's outstanding issues. On February 11, 1986, NuPac submitted Revision 2 of the SAR to NRC for review. Based on the information supplied by NuPac and GPU Nuclear, the NRC TCB issued Revision 0 of the CoC for the NuPac Model 125-B cask on April 11, 1986. This was a major milestone in the TMI-2 core debris shipping campaign and the result of excellent performance by the many organizations that contributed to the achievement. From the contract award date to issuance of the CoC required 23 months and nearly marked the end of cask licensing activity before the first loaded shipment of a cask.

Detailed review by GPU Nuclear of the CoC as issued by NRC raised concerns needing clarification and prompting minor revisions to the SAR and CoC. As a result, NuPac prepared and then submitted Revision 3 of the SAR to NRC on June 11, 1986. The revision expanded the description of the non-fuel materials allowed to be shipped in a canister; specified that the use of argon, nitrogen, or helium was acceptable as a cover gas to inert the canisters and the ICV and OCV cask cavities; clarified free water in the inner vessel cavity relative to dry loading of the cask; requested permission to use a helium leakage rate test rather than a pressure rise test during assembly of the cask; revised the canister criticality analyses to incorporate optimal fuel lump size; revised the seal materials and bolt torques used for fuel canisters; and other minor changes.

Subsequently, on June 30 and July 16, 1986, as part of Revision 3, NuPac also requested minor changes to the SAR for the acceptance criteria for installation of the criticality moderators. These minor GPU Nuclear and NuPac requests were approved without written questions from NRC and the changes were reflected in Revision 1 of the CoC issued July 17, 1986. This revision completed all licensing needed prior to the start of the first shipment of TMI-2 core debris on July 20, 1986.

A closely related subject is NRC's audit of NuPac's fabrication of the casks, which is discussed in Section 2.5.5.1.

2.5.3.1 Quarter-Scale Cask Model Drop Testing. Drop tests of a quarter-scale cask model were very successful technically and proved invaluable in supplying data needed by NRC in the licensing effort for the cask. The results of the testing were documented in the SAR and supported the analyses that led to NRC approval of the cask design.

Actually, two different sets of drop tests were performed in developing the NuPac 125-B cask.

The first set was in an engineering development test program performed by NuPac near their Federal Way, Washington, offices. The second set was in the quarter-scale cask model drop test program performed at SNL.[25]

The engineering development tests were performed in January 1985 to determine impact behavior of the cask overpacks. The cask and overpacks were required to limit loads to the canisters to less than 40 g (axial) in an end drop and 100 g (lateral) in a side drop. This performance was principally controlled by the type, density, and thickness of the foam used to fill the overpacks, although internal impact limiters were also used for controlling the axial loads to the canisters. The results of these overpack performance tests assisted in specifying foam properties and also showed that the attachments of the overpacks to the cask needed to be redesigned.

The quarter-scale cask model was fabricated by NuPac starting in early 1985. The test article had linear dimensions that were 1/4th, and a weight that was 1/64th, of the full-size package. The materials of construction were identical to those of the actual package, with all structural details accurately represented. Certain nonstructural features were omitted, or not scaled, including rupture disc ports, canister grapple sockets, and surface finishes. Internal structures of canisters were not modeled but external size and mass were accurate.

The test unit arrived at SNL in mid-March and drop test activities were completed by early May. A total of five tests were performed on the unit. Three tests were free-fall drops from 9 m (30 ft) with impact onto a flat unyielding surface. Two tests were free-fall drops from 1 m (40 in.) onto a puncture bar.

Although NRC's performance requirements require only a single drop from 9 m (30 ft) onto a flat surface followed by a single drop from 1 m (40 in.) onto a puncture bar, multiple free-drop and puncture tests were performed on one test unit. The multiple tests were required because a single sequence of the two worst orientations for damage to the package was unknown before performing the test program. Different orientations for impact of the cask result in worst-case damage to different package components. To ensure that the worst-case combination of orientations was tested, the five different tests were conducted to bound all possible combinations.

The three 9-m (30-ft) drop orientations were:

- End drop onto the bottom impacter limiter (overpack) to determine the maximum acceleration response of the lids and closure bolts and to show that the internal impact limiters in the ICV protected the canisters from excessive axial loads (see Figure 2-7).

- Oblique impact on the lid end to determine the maximum stresses in the shells forming the outer cask body. The orientation of the package with respect to the horizontal surface is shown in Figure 2-8.

- Side drop to determine the maximum loads to the ICV (see Figure 2-9).

The two 1-m (40-in.) puncture drop orientations were:

- Onto the center of the closure end to show the integrity of the lid (see Figure 2-10)

- Onto the center of the side to show the integrity of the cask body's sidewall (sandwich construction of outer steel shell, lead, and inner steel shell) (see Figure 2-11).

Both the bottom end and oblique drops were performed at a temperature of -29°C (-20°F), which is the worst-case initial temperature for these two orientations. The remaining tests were performed at ambient temperature. All five tests were performed at ambient internal pressure, which is worst case for these drops.

Concerns about over-testing a single package were discussed before the start of the test program. A NuPac test engineer was present at all tests to review the cumulative damage to the package and determine if testing should continue on the same package. NRC did not require all

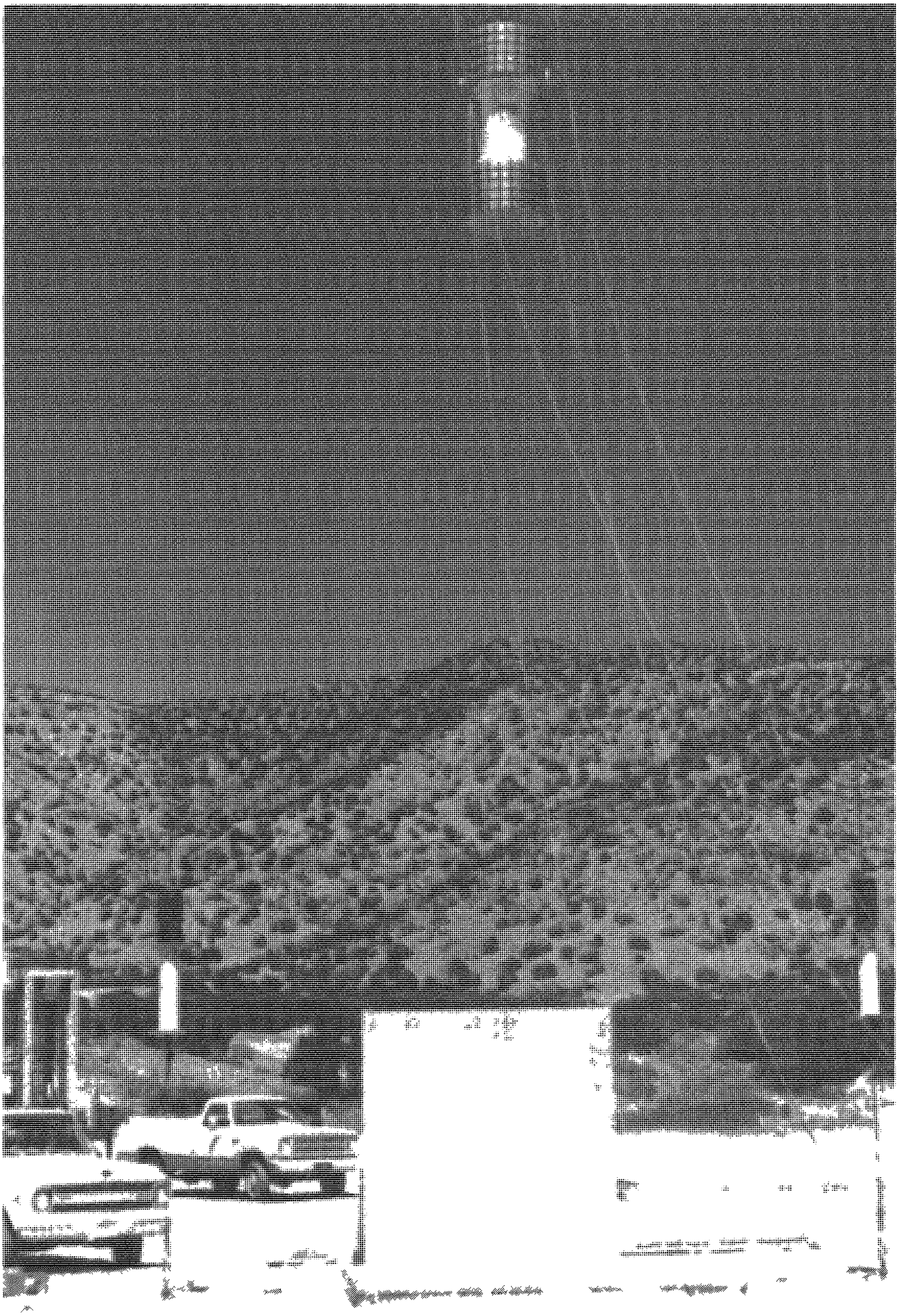

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Figure 2-7. Bottom end drop from 9 m (30 ft)

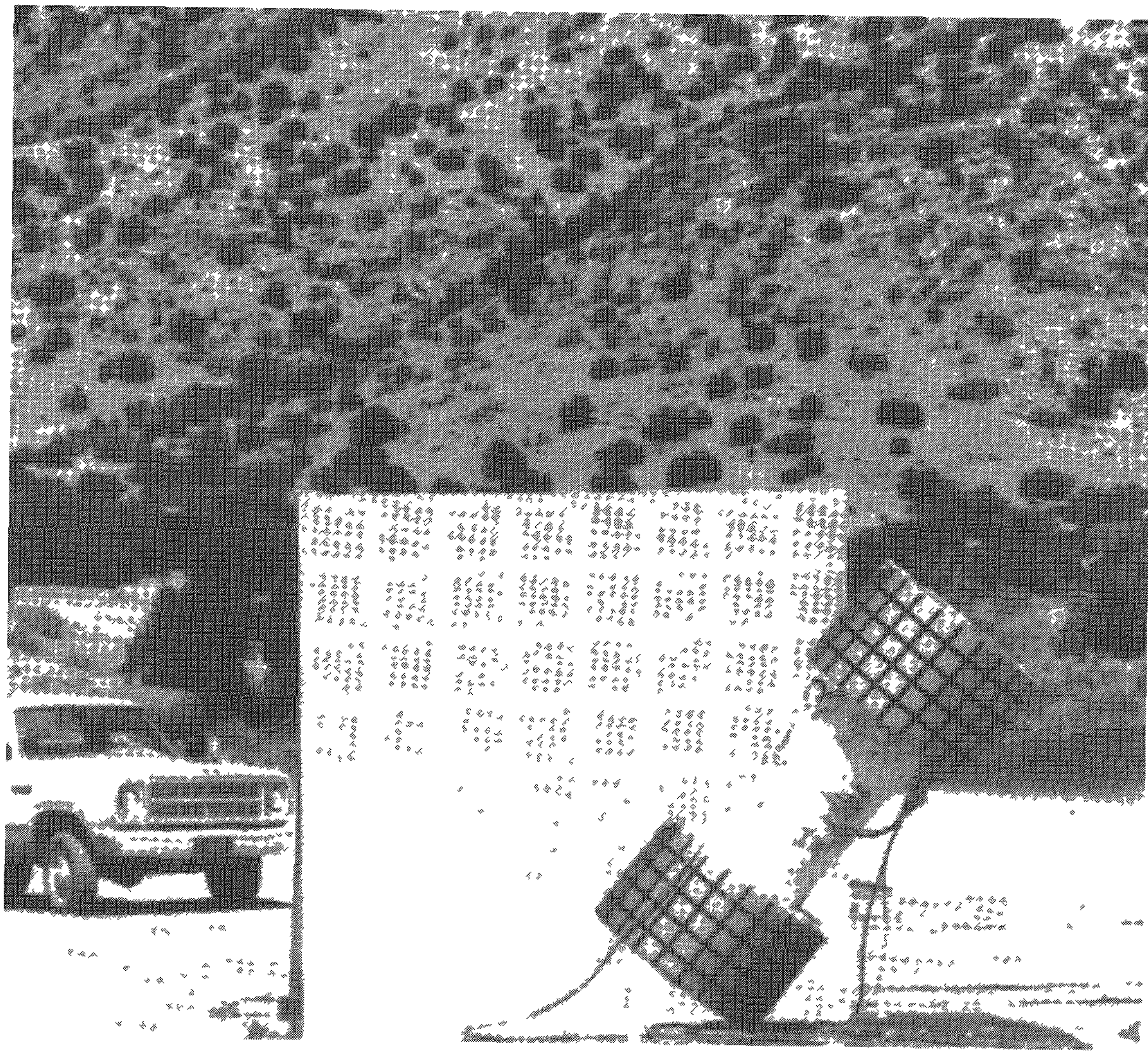

Figure 2-8. Oblique drop from 9 m (30 ft) at the instant before impact (stadia board is behind model).

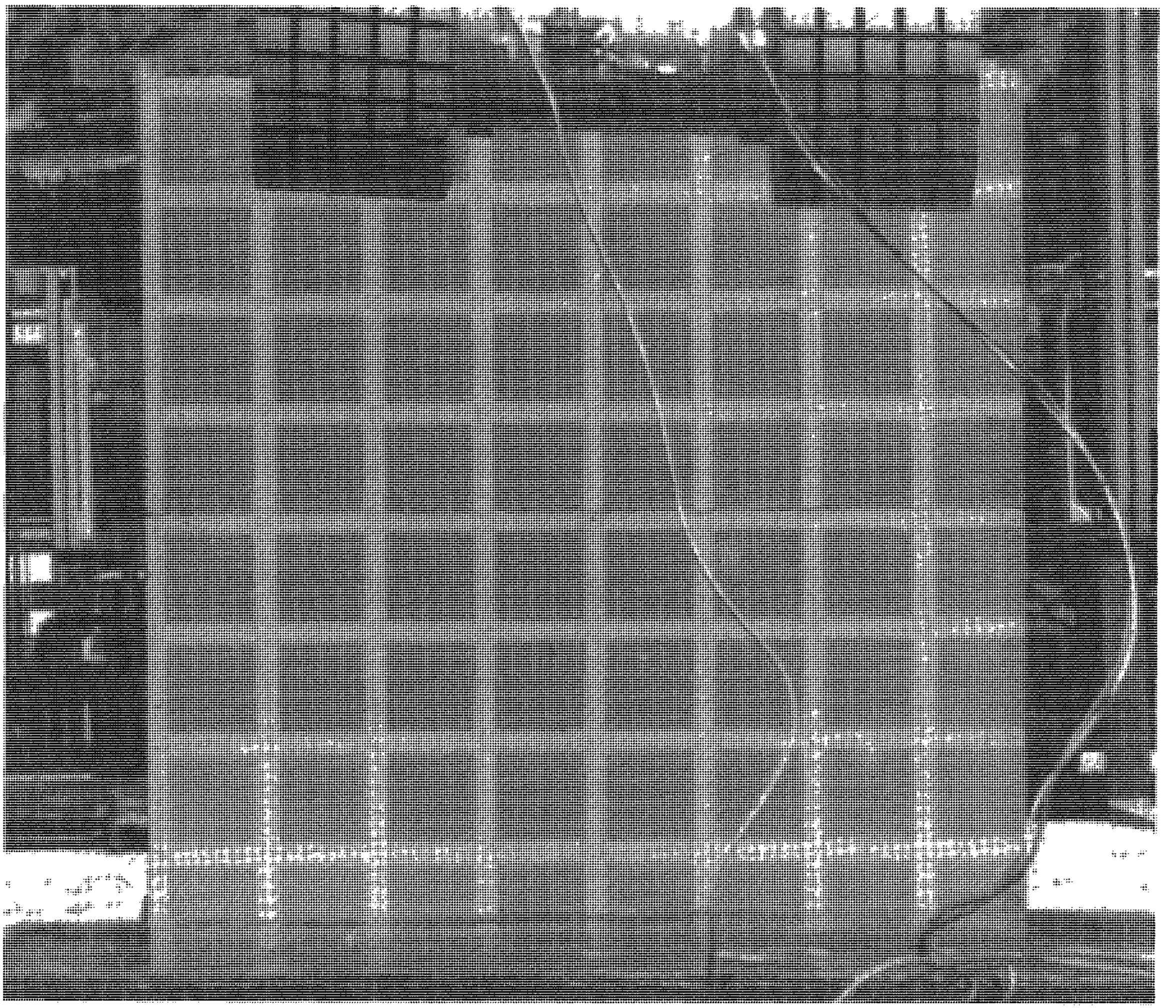
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Figure 2-9. Side drop from 9 m (30 ft) during free fall.

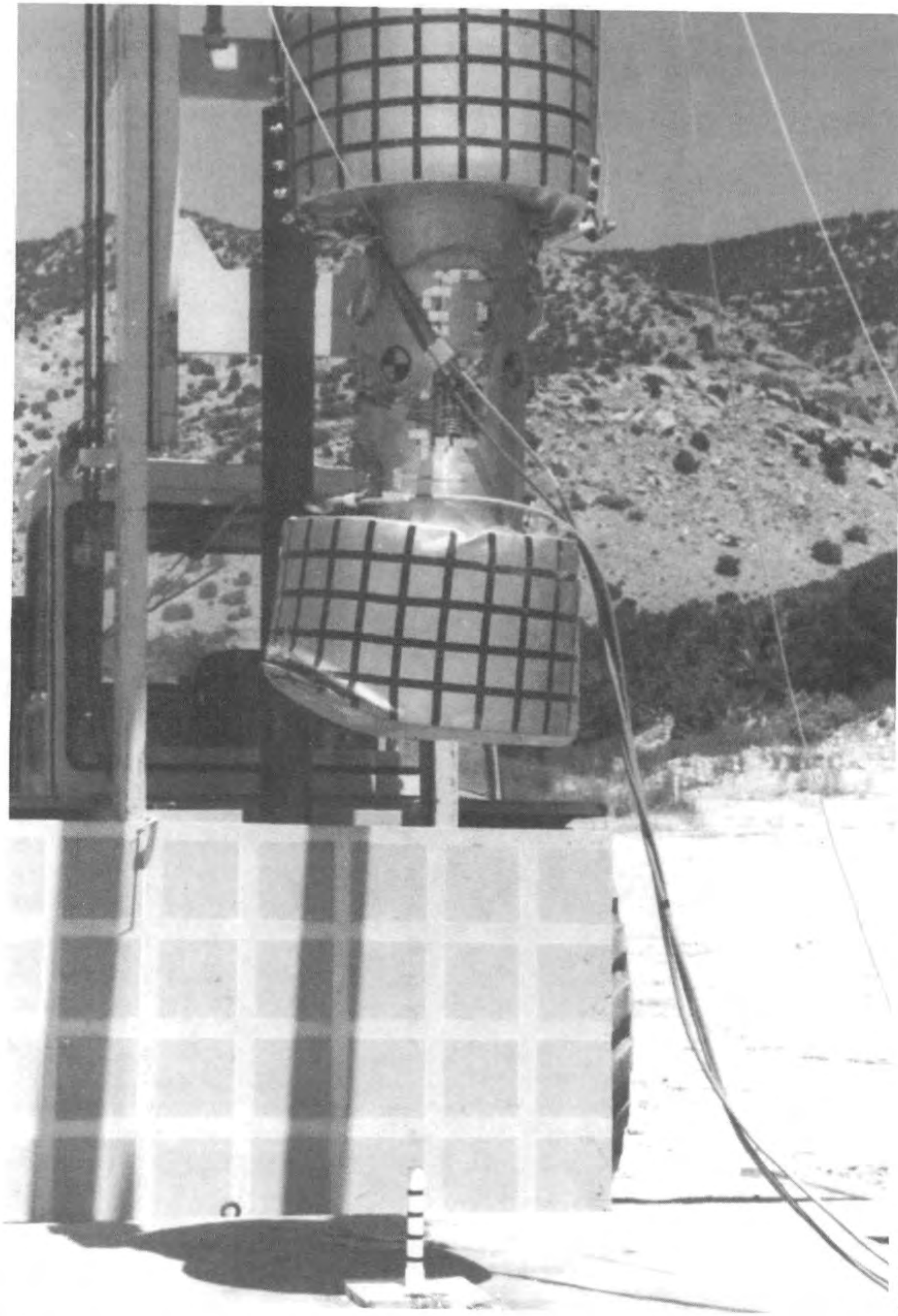


Figure 2-10. End puncture drop from 1 m (40 in.) verified that the cask lid could withstand an impact of the cask hitting a blunt object during an accident.

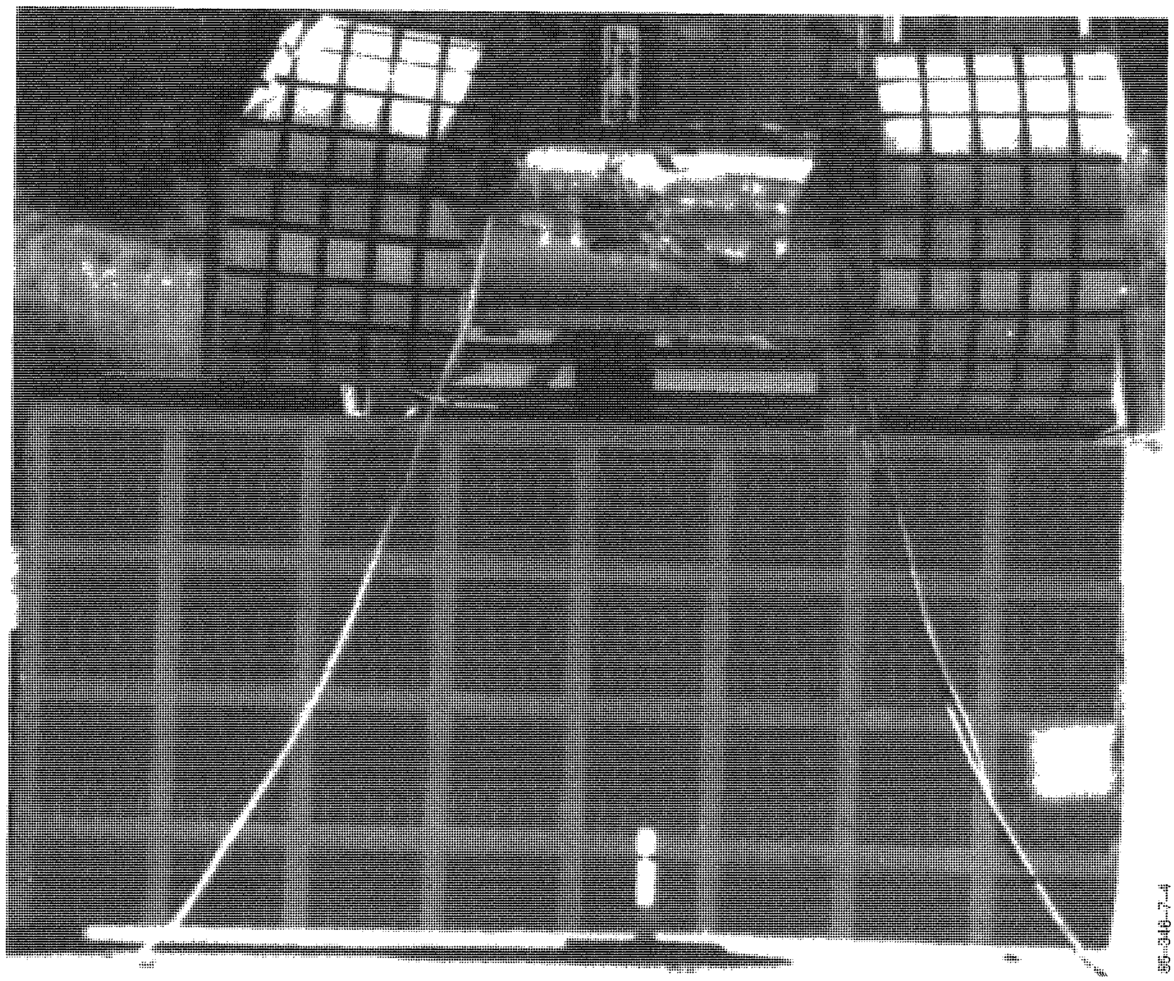


Figure 2-11. Side puncture drop from 1 m (40 in.) verified that the cask side walls could withstand an impact of the cask hitting a blunt object during an accident.

three 9-m (30-ft) and two puncture drop tests on a single package. Up to three different packages could have been used but would have been more expensive.

The principal results of the tests showed that containment integrity and criticality-safe geometry were maintained. Results from the tests were that:

- Leakage rates for the containment vessels did not degrade from the "leaktight" conditions before the tests
- Neither the outer cask body nor the inner vessel had geometric changes that permanently altered the shape or spacing of the canisters.

While seals were not considered to be tested directly in the scale-model test program, the post-test leakage rates showed that the containment boundaries of the vessels did not deform to compromise seal integrity or rupture as a result of the tests. Damage to the cask body was limited to a localized dent and a slight ovalizing in the outer shell of the sidewall that resulted from the side puncture drop.

The overall results were an excellent correlation between analytical predictions and scale-model behavior.[26] The tests supported the assumptions used in the analyses in the SAR. Together, the tests and analyses demonstrated the performance of the package in meeting NRC's requirements and were key to a straightforward approval by NRC.

Test data recorded by SNL included outputs from several accelerometers and strain gage rosettes. Visual observations were made using video tape, normal-speed photographs, and high-speed motion picture films.[27] These records of the tests were very important in demonstrating the integrity of the package to the public and other interested audiences.

2.5.3.2 Special Hazards Evaluations. The special hazards evaluations performed for the TMI-2 core debris shipments considered pyrophoritcity, water content of the canisters during shipment, and radiolytic gas generation.[28] RHO, as a support contractor to the DOE's Richland, Washington, field office, was responsible for the effort.

Pyrophoricity was a minor technical concern for the TMI-2 core debris shipments. The concern was due to the possible presence of small particles of zirconium from damage to the zircaloy-clad fuel pins in the core. Finely divided zirconium is known to spontaneously ignite under certain conditions. However, this was also a concern for defueling of the reactor and considerable testing was performed that determined that the zirconium in the TMI-2 core debris was not pyrophoric, largely because of oxidation. Furthermore, the environment of the core debris during the shipments essentially eliminated the potential for pyrophoricity due to use of an inert cover gas in the canisters.

Water content of canisters was also a minor concern. Initially, this concern was due to the potential for heating of cask and contents during a transportation fire accident and overpressurization of canisters containing water. Design of the NuPac 125-B cask with a massive amount of steel and lead limited the potential rise in canister temperatures to less than 93°C (200°F) after exposure to the hypothetical fire accident conditions in NRC's regulations. For an "extended" fire with a higher heat input than required by NRC's regulations, a rupture disc is incorporated into the lid of both cask containment vessels.

Radiolytic hydrogen and oxygen gas generation was a concern for the core debris shipments because of the drip-dry condition of the material in the canisters. Wet debris resulted in water in close contact with the fuel. Radiolysis of water produces hydrogen and oxygen gases in proportion to the amount of ionizing radiation absorbed by the water.[29] As a closed system, canisters of core debris could have experienced a buildup of these gases, so recombiners were installed in each canister to control the concentrations and ensure an acceptable degree of safety.

Rockwell conducted a series of tests of four different catalysts to determine their effectiveness in recombining hydrogen and oxygen.[30] Performance was tested at rates that exceeded the probable-maximum rate expected from radiolysis of the water associated with a canister of wet core debris. The tests were used to determine the effects of catalyst type, catalyst bed size and shape, and cover gas type and pressure. The tests evaluated handling/shipping conditions that might affect catalyst performance, including wetted catalyst beds; submerged beds; beds poisoned with waterborne chemicals, insoluble particulates, and carbon monoxide gas (potentially generated radiolytically from organic substances); frozen catalysts; and heavily irradiated catalysts.

The test program successfully determined the mix of catalysts types, the design concepts for bed size and shape, and the design requirement for bed locations in canisters. The results ensured a safe and reliable method for control of hydrogen in the TMI-2 core debris canisters.

2.5.3.3 Canister Drop Test Program. Drop tests of partial-length and full-length canisters were a technical success and supplied the data requested by NRC in approving the designs for transport. Results from separate sets of tests were prepared by B&W for GPU Nuclear and incorporated by NuPac into both the initial submittal of the SAR and a subsequent revision. The tests helped to define the behavior of the criticality control structures under the hypothetical accident conditions of transport and the positions of those structures as inputs to the criticality analyses.

Initial canister drop tests were performed by B&W on the design configuration of the fuel canister at the time of the test. Some of those results are applicable to all three designs. For example, the tests showed that there was a lack of significant permanent deformation of the canister shell, heads, skirt, and fittings.

The most direct tests of the final design of the fuel canister were a vertical orientation test of a full-length canister from a drop height of 5.5 m (18 ft) and a side orientation test of a partial length canister from 9 m (30 ft). In the vertical drop test, the lower support plate and its weld were shown not to deform significantly, which prevented core debris from entering the lower head. Also, only minor local deformations of the boral shroud resulted due to pieces of simulated debris jammed against the inside. In the side drop test, the LICON concrete supported the shroud and prevented deformations that would have adversely affected the criticality analyses.

In response to NRC's questions on the structural analyses of the knockout canister design in the SAR as originally submitted, tests of a full-sized knockout canister were coordinated through EG&G Idaho and performed at DOE's Oak Ridge National Laboratory.[31] The tests used a canister fabricated from parts selected from those produced for use at TMI-2. Minor nonstructural modifications were made to facilitate the tests. In particular, screens were attached to the uppermost spider support plate for use in a test. Lead shot and water were used to simulate the TMI-2 core debris. The results provided for direct measurements of the deformations of the criticality control structures (strongback tube, poison rods, and support plates), which conclusively demonstrated the safety capabilities inherent in the design.

One canister was dropped four times from 9 m (30 ft) in the test program. For each test, the canister was placed into a slightly larger diameter pipe to simulate a canister inside of the NuPac 125-B cask during a transport accident. The sleeve was called the cask simulation vessel and had foam impact limiters to control the load to the canister in each drop test.

Four drops were performed on one canister to ensure that the worst-case orientation for damage to the criticality control structures would be tested. The configurations used in the tests are shown in Figure 2-12, including the orientation of the canister and the position of the simulated core debris.

A drop onto the bottom of the canister that was oriented vertically was the first test. Before the test, the simulated debris was frozen to one side of the canister while the canister was lying on its side. At impact, the debris was then in a position to impart the maximum force to bend the support spiders and bottom support plate. A maximum crippling load was placed on the poison rods and central strongback tube.

A side impact was the second test. The simulated debris was again frozen before the test while the canister was on its side. Just prior to the test, the canister was rotated 180 degrees when placed into the cask simulation vessel so that at impact the debris was at the top above the criticality control structures. In this position, the debris imparted a maximum force to bend the poison rods and buckle the support spiders' arms.

Another vertical orientation drop was performed for the third test, onto the top of the canister. The screens attached to the uppermost spider support plate captured the unfrozen simulated debris above the plate. In this position, the debris imparted a maximum force to try and pull the strongback tube from its weld to the support plate. The intermediate spider support plates also had bending forces from the flow of the debris at impact.

The last test was another side drop. The debris was again frozen and the canister was rotated 90 degrees when placed into the cask simulation vessel so that all material was to one side of the canister. In this position, the debris imparted the maximum force to twist the internal assembly at impact.

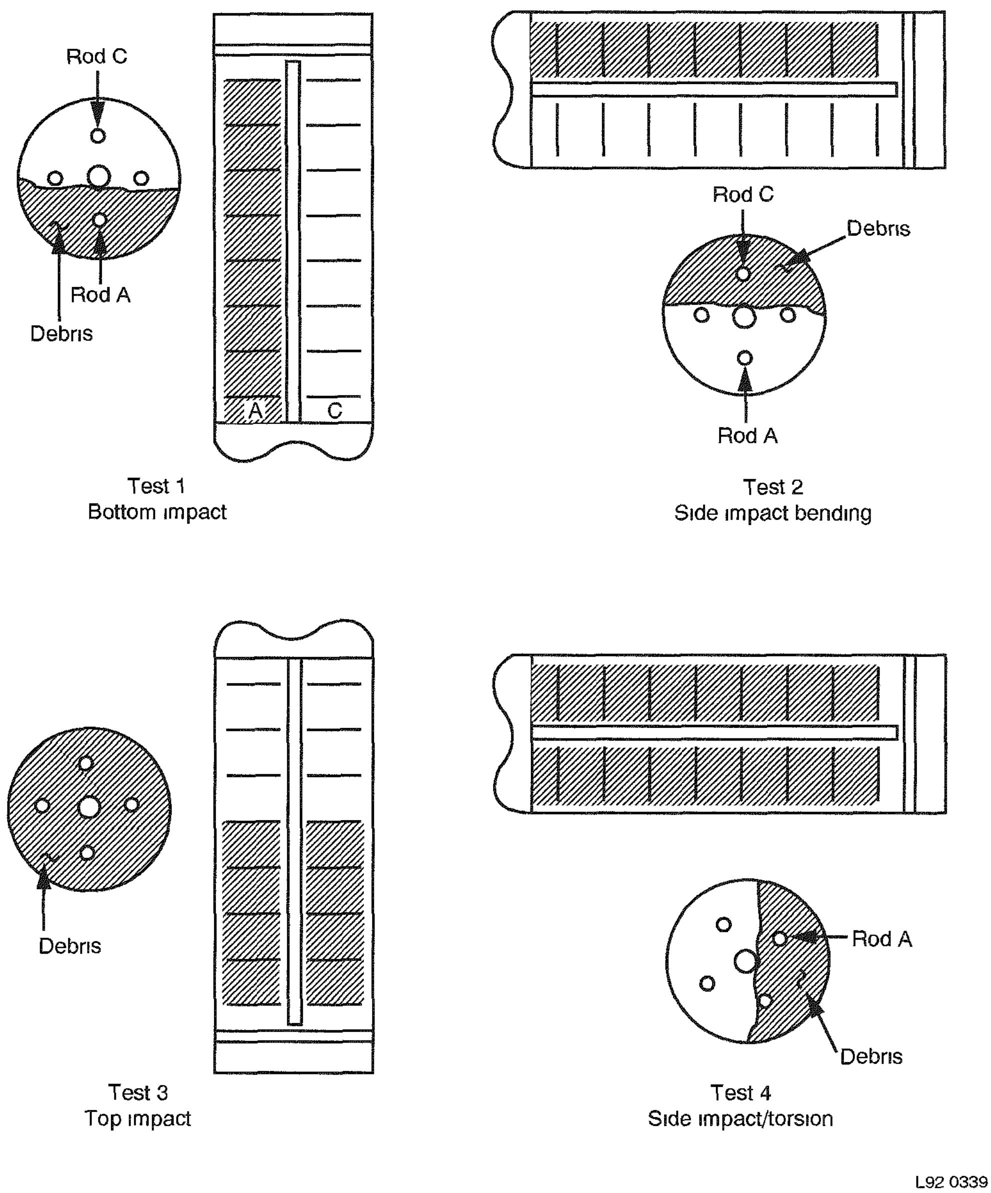


Figure 2-12. Canister drop test configurations.

Figure 2-13 shows a photograph of the preparation of the cask simulation vessel for a knockout canister side impact test.

The tests demonstrated that no significant deformations resulted from the drops. The positions of the canister's criticality control structures were within the assumptions used in the criticality analyses. There was no migration of simulated core debris into the lower head, which validated the model used in the criticality analyses. There was no significant change to the shape of the shell. The canister remained pressure tight after each of the drop tests, and no evidence of leakage of simulated debris was found outside of the canister.

Following the testing efforts, B&W prepared the revision to the canister appendix in the NuPac 125-B cask SAR. The results were incorporated into Revision 1 by NuPac and submitted to NRC.

2.5.4 Railcars. Selection of the design of the railcar to transport the NuPac 125-B rail cask became a significant issue in making preparations to transport the core. The issue had many facets, but primarily involved load carrying capacity and a desire for a conservative margin of safety, an increase in cask weight caused by a canister diameter increase, railcar-to-TMI-2 facility interface problems (overall car length, for example), and so forth. NuPac conducted an extensive investigation of the characteristics of available railcar designs from manufacturers. Facility interfaces with GPU Nuclear and the INEL were considered. A search for suitable existing railcars already in use elsewhere within the DOE complex was also conducted by EG&G Idaho without success.

The railcars that were finally selected were 8-axle, heavy duty, 152-metric-ton (167-US-ton) railcars produced by Maxson Railcar, Inc. The railcar originally proposed by NuPac was a 100-US-ton, 4-axle, heavy duty flatcar. A principal alternative to the selected railcar was a 4-axle, heavy duty, 115-US-ton, depressed-center flatcar.

The final selection to use an 8-axle railcar was based on a combination of factors. The cask weight increase resulting from the canister diameter increase made the originally proposed 100-US-ton capacity railcar unacceptable. While both the 115-US-ton and the 167-US-ton railcars had adequate load carrying capacity, the 8-axle railcar with its larger capacity had a greater margin of safety for the cask than the 4-axle railcar. As with many other activities undertaken by DOE in the TMI-2 core debris transport program, DOE was opting for extra safety and conservative choices throughout this campaign. Acceptance of EG&G Idaho's recommendation to select the higher load carrying capacity railcars was another decision consistent with this philosophy.

The selection of the 8-axle railcars facilitated resolution of other issues associated with cask handling at TMI-2. Importantly, the bridge across the river to the site had a per-axle limit of 25 tons, which would have been exceeded by the 4-axle railcar. Also, the 8-axle design was needed to move a cask into the truck bay for the dry loading process. The TMI-2 truck bay was actually an area in the TMI-site Fuel Handling Building (FHB) common to both TMI-2 and TMI-1. The truck bay was directly above cabling for TMI-1 safety-related equipment routed through the building's basement. To avoid safety issues relative to lifting of heavy loads above these safety circuits, a choice was made to not allow the wheels of the railcar to enter the exclusion zone, an area above the circuits in the truck bay. This choice then required placing the cask and skid offset from the center of the railcar. The heavier duty 8-axle railcar was needed to allow the cask and skid to be partially offset lengthwise. A drawing of the cask and skid on the railcar is shown in Figure 2-14.

The railcars are flat deck cars. Figure 2-15 is a photograph of an assembled rail cask system with callouts added to identify the major subassemblies. As shown in the photograph, each end of the flat deck body interfaces with a "span bolster" assembly. Figure 2-16 is an exploded view of the railcar. As shown in the exploded view, the span bolster is a heavy frame assembly that distributes

Figure 2-13. Cask simulation vessel with impact limiters spaced equally along horizontal length

the load at each end of the car body equally between two "truck" assemblies and articulates the movements between the car body, trucks, and coupler Each truck assembly distributes its load equally between two axles, so that ultimately, the load from the railcar and cask assembly is distributed among two span bolsters, four trucks, eight axles, and sixteen wheels

The underside of each end of the car body has a thick circular plate, known as the center plate, welded into the body structure That plate serves as the connecting pin between the body and the span bolster Outboard from each center plate (toward the sides of the car) are small rectangular wear plates welded to the body understructure that mate with similar plates on top of the span bolster Those mating pairs of plates are known as side bearings, and they function to limit tilt of the car body relative to the span bolster When the car is level, there is a specified clearance between the surfaces of the side-bearing wear plates

The receptacle in the span bolster that interfaces with the car body center plate is known as the "center bowl " The mating surfaces of the center plate are surface hardened, so the center bowl is lined with a wear ring around its vertical bore, with a wear plate in the bottom of the bowl A heavy lubricant is applied to the wear plate to provide a bearing material in the assembled connection The underside of the span bolster at the interface with each rail truck is similar to the car body configuration (i e , center plate and side bearings)

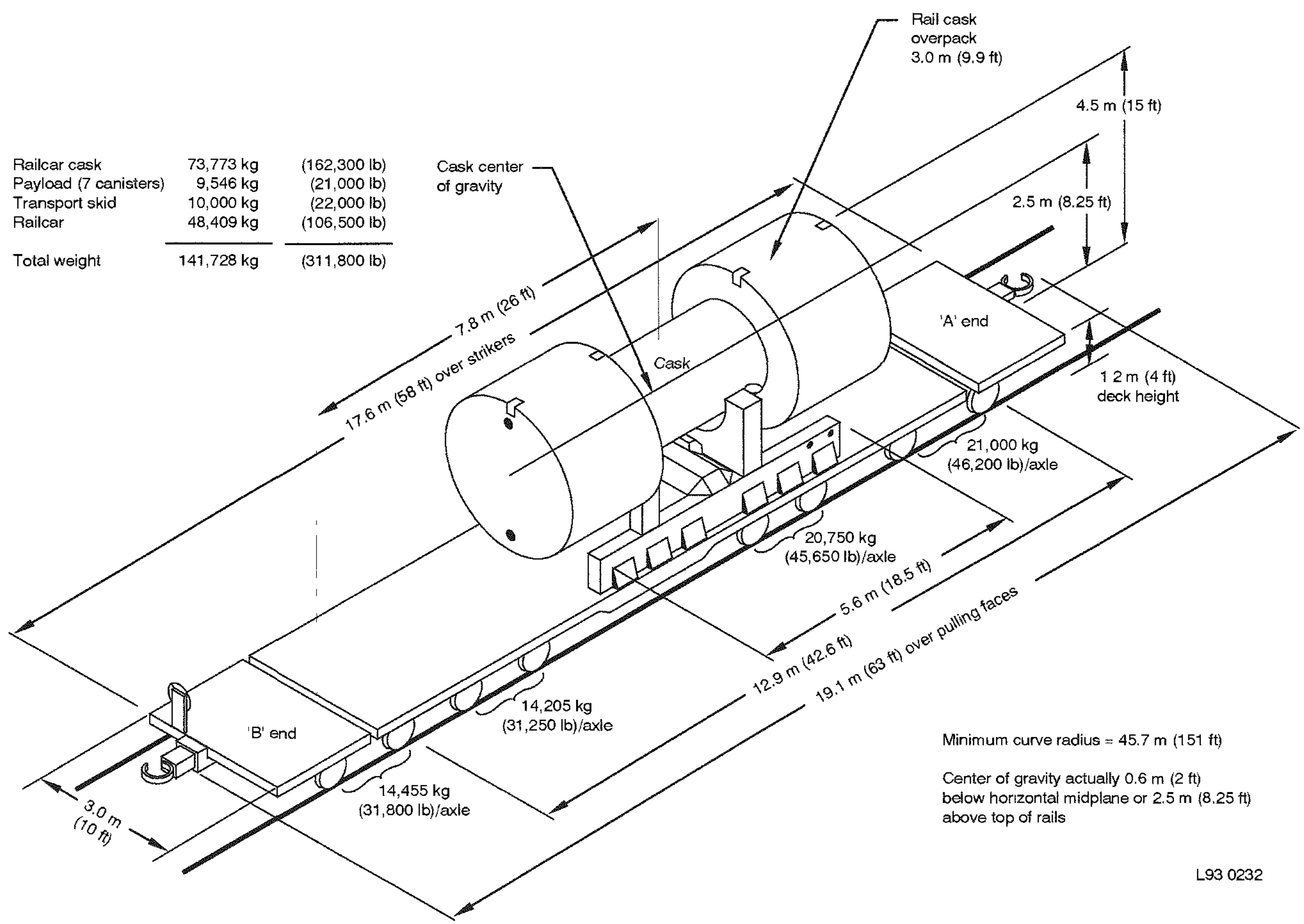


Figure 2-14. Diagram of the NuPac 125-B cask and railcar with overall dimensions and weights of the system.

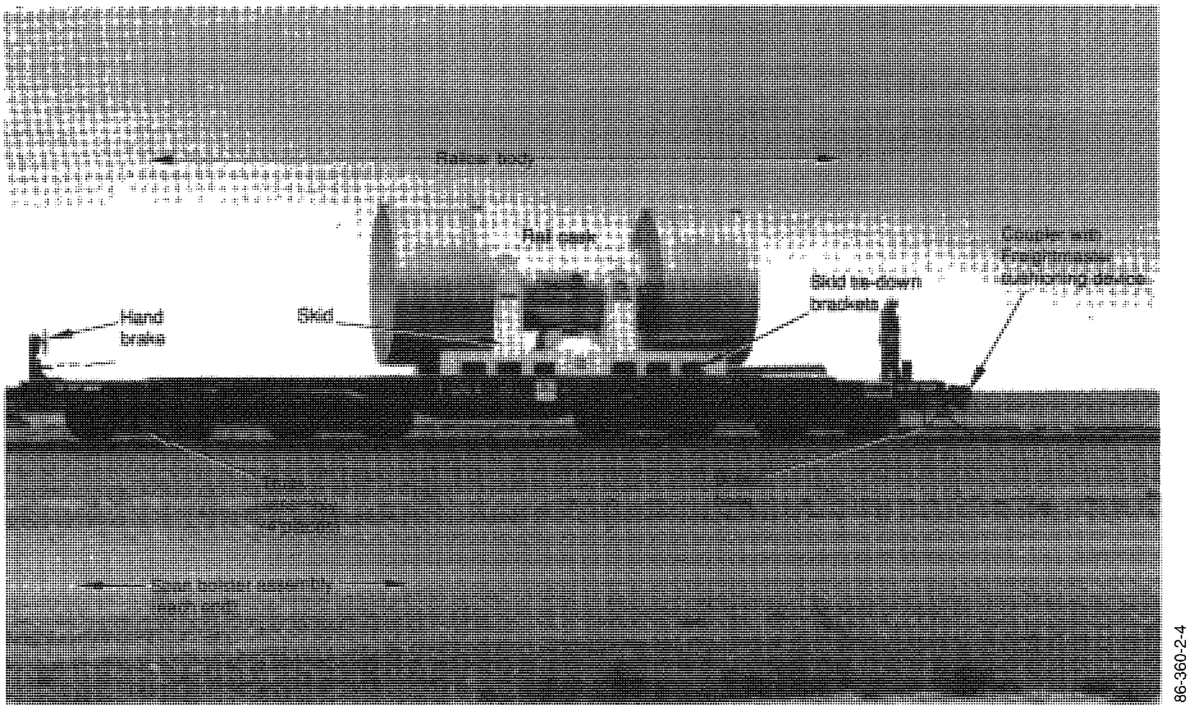


Figure 2-15. Assembled rail cask system.

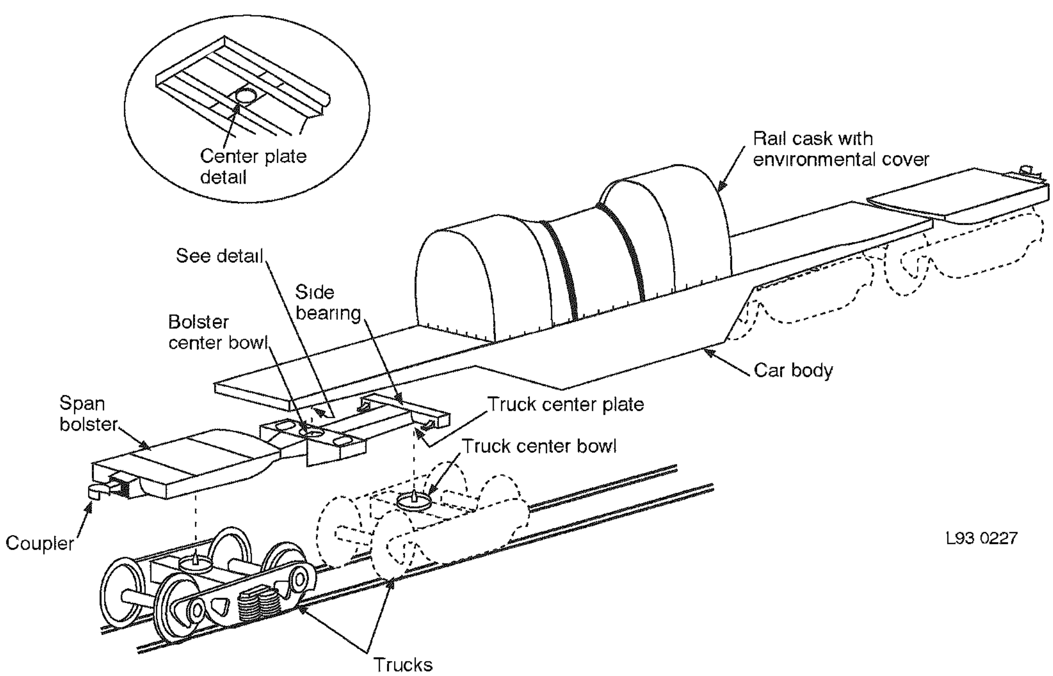


Figure 2-16. Exploded view of railcar.

The frame of the span bolster is extended at one end to provide an interface with the railcar coupler system. The span bolster frame is built to accommodate a Freightmaster drawbar cushioning device, and the Freightmaster unit, in turn, accepts a standard railcar coupler unit.

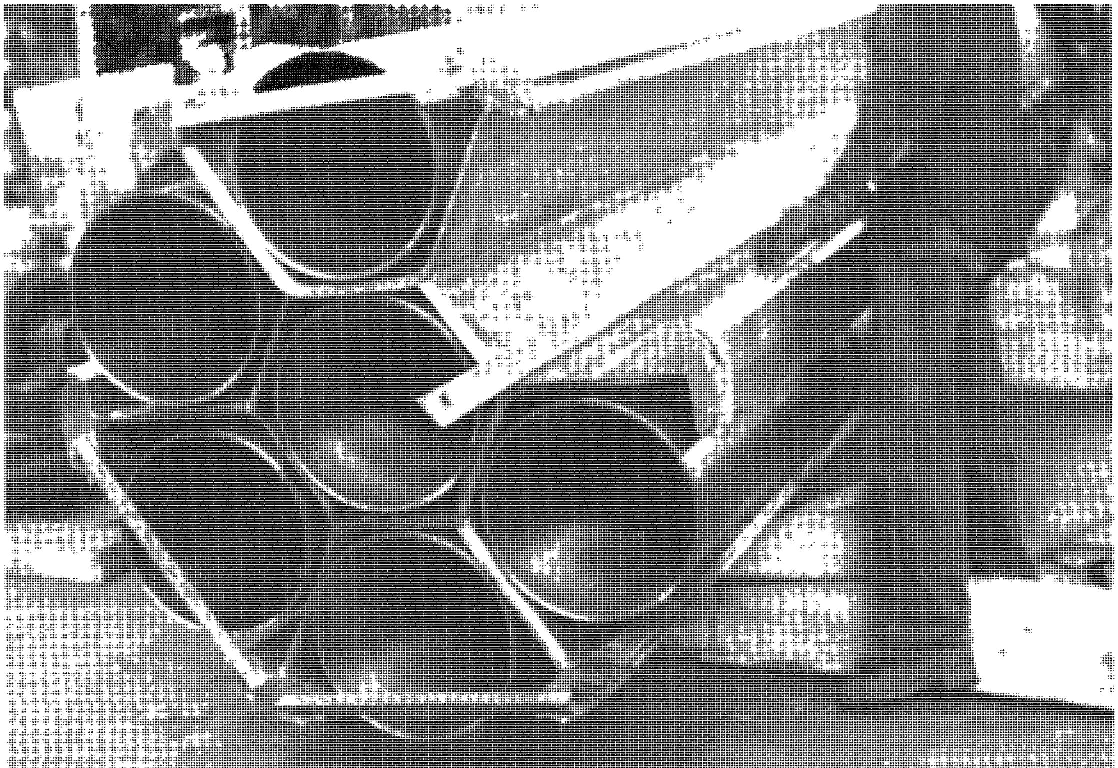
The structures on the outboard sides of each truck assembly are called side frames. The side frames interface with the roller bearing housings on the ends of each axle and with a structural cross-member running across the center of the truck, known as the truck bolster. The truck bolster interfaces with each side frame through a set of linear guides and the rail truck spring assemblies. Each truck bolster contains a center bowl for the respective span bolster center plate, and side bearings limit the tilt of the span bolster relative to the truck. The truck assemblies also contain all mechanisms, linkages, and air cylinders necessary for the brakes, which interface with each wheel.

2.5.5 Cask Fabrication. Fabrication of the NuPac 125-B rail casks was performed in parallel with cask licensing activities. NuPac accepted the risk that the cask would not be approved as built. This risk was minimized by frequent meetings with NRC to present the cask design as it evolved and successful completion of the quarter-scale cask model drop test program. Only long-lead materials (shells and forgings) were ordered before completion of the drop tests. Following the successful tests, fabrication of the cask components proceeded with some certainty that the cask design would not change.

The casks were fabricated at several of NuPac's subcontractors' facilities. The subcontractors contributing significantly to cask fabrication were Olympic Northwest Industries, Inc., Port Orchard, Washington, for the OCVs, the rail cask transport skids, the cask overpacks, and final cask assembly; Chicago Bridge and Iron, Salt Lake City, Utah, for the ICVs; Maxson Corporation, St. Paul, Minnesota, for the railcars; Metalex, Ltd., Richmond, British Columbia, for installation of the lead by a pour of molten lead into the OCVs; General Plastics, Inc., Tacoma, Washington, for the foam in the overpacks; Nooter Corporation, St. Louis, Missouri, for the heavy rolled plate used in the shells of the OCVs; Gulfco, Beaumont, Texas, for the OCV and ICV forgings; and Wisconsin Centrifugal, Wausau, Wisconsin, for the spun cast tubes in the ICVs. Fabrication activities at several of the facilities are shown in Figures 2-17 through 2-20.

Not all activities associated with cask fabrication went smoothly; often, the case was the opposite. Many problems surmounted during manufacturing were accentuated by the intense scrutiny placed on the tight schedule. At the same time as cask fabrication, design and fabrication of cask handling equipment was performed by some of the same manufacturers. Also, changing requirements at TMI-2 for cask handling equipment and acceleration of the date for start of defueling altered the needed delivery date for the cask and its support systems. During this whole period, there was considerable concern by DOE-HQ organizations regarding fabrication and delivery schedules, much of which was attributable to earlier confrontations over the cask vendor selection and the resulting GAO protest with its spinoff Congressional interests. Considerable DOE pressure was placed upon EG&G Idaho to ensure that the cask vendor performed to meet the schedular needs for the start of defueling, which in June 1984 had moved forward from January 1987 to December 1985.

EG&G Idaho used several methods to achieve DOE's goal for cask delivery. A resident engineer, highly experienced in metal fabrication processes, was assigned to NuPac's offices to closely track performance of NuPac and its subcontractors and to report progress and problems. A subcontract administrator addressed specific problem areas with an incentive clause in the contract and with contractual pressure, as feasible. A full-time quality engineer overviewed quality-related activities to ensure that the fabricator's quality assurance (QA) program met CFR requirements, and that the product met technical requirements. Also QA reviews, plans, and inspections focused on prevention and early detection of problems. This approach to QA goes beyond 10 CFR 71 requirements, but was



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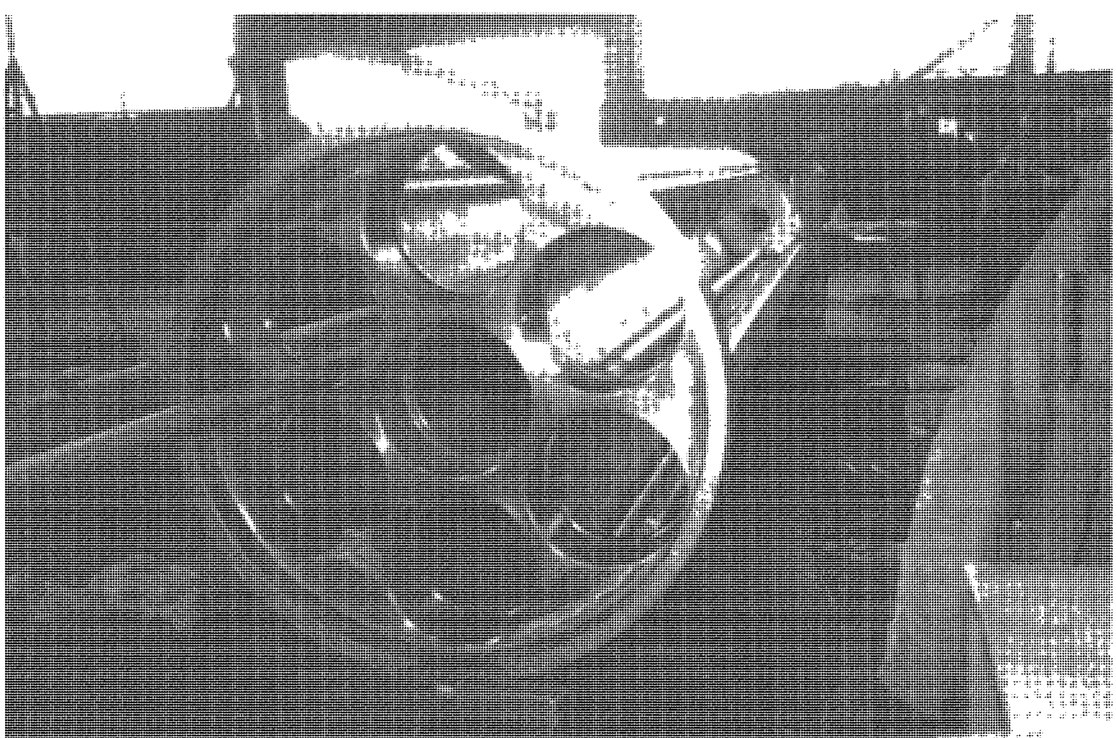

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Figure 2-17. Fabrication of an ICV.

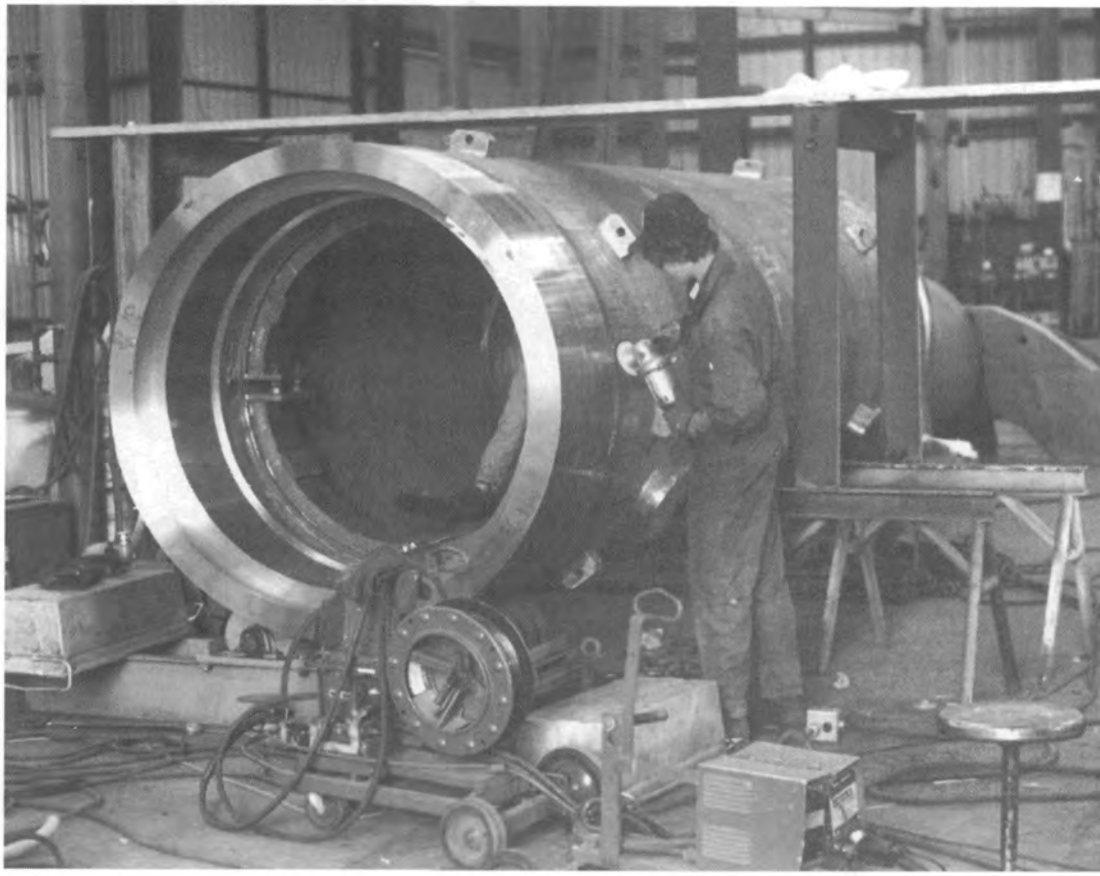

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Figure 2-18. Fabrication of an OCV.

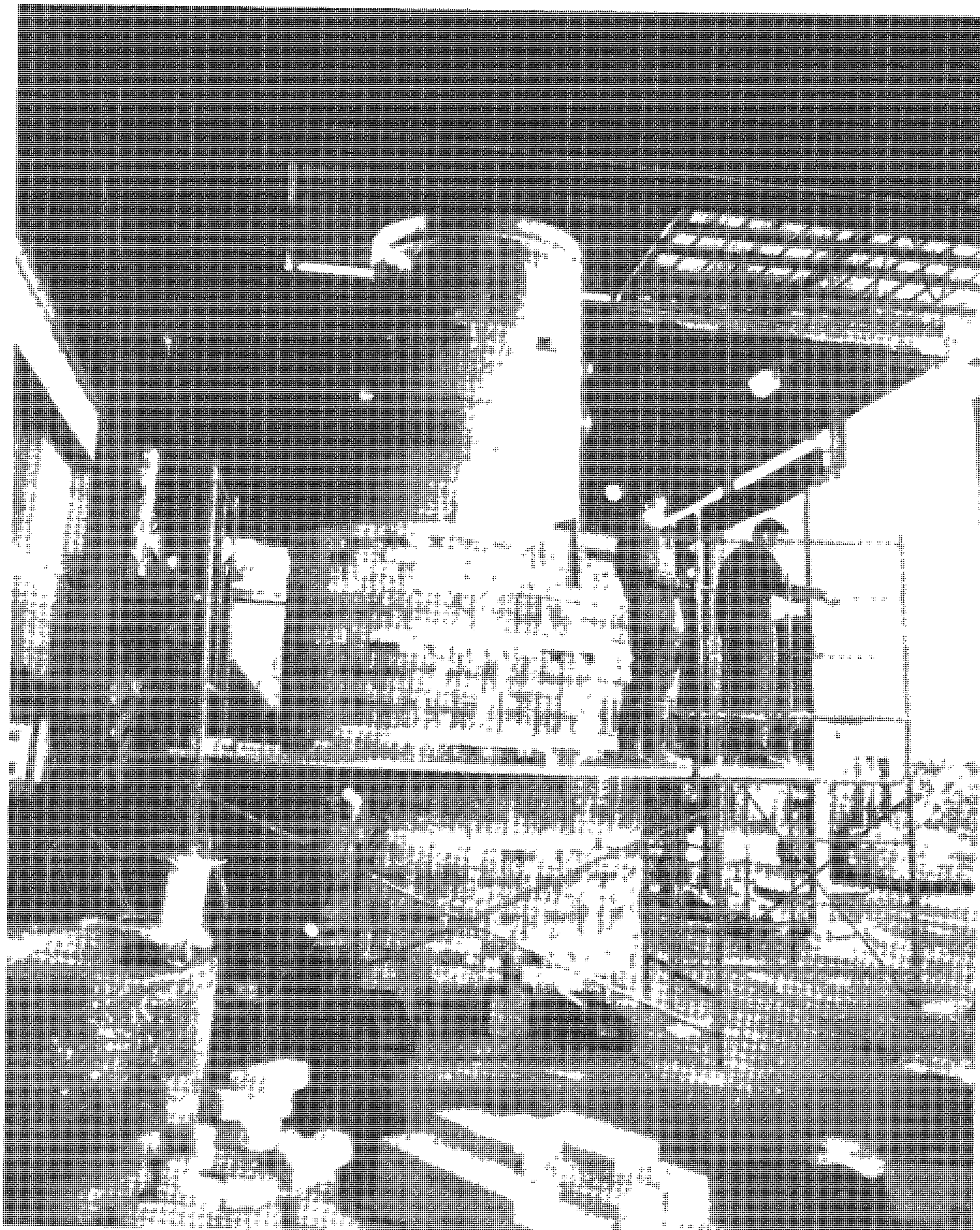
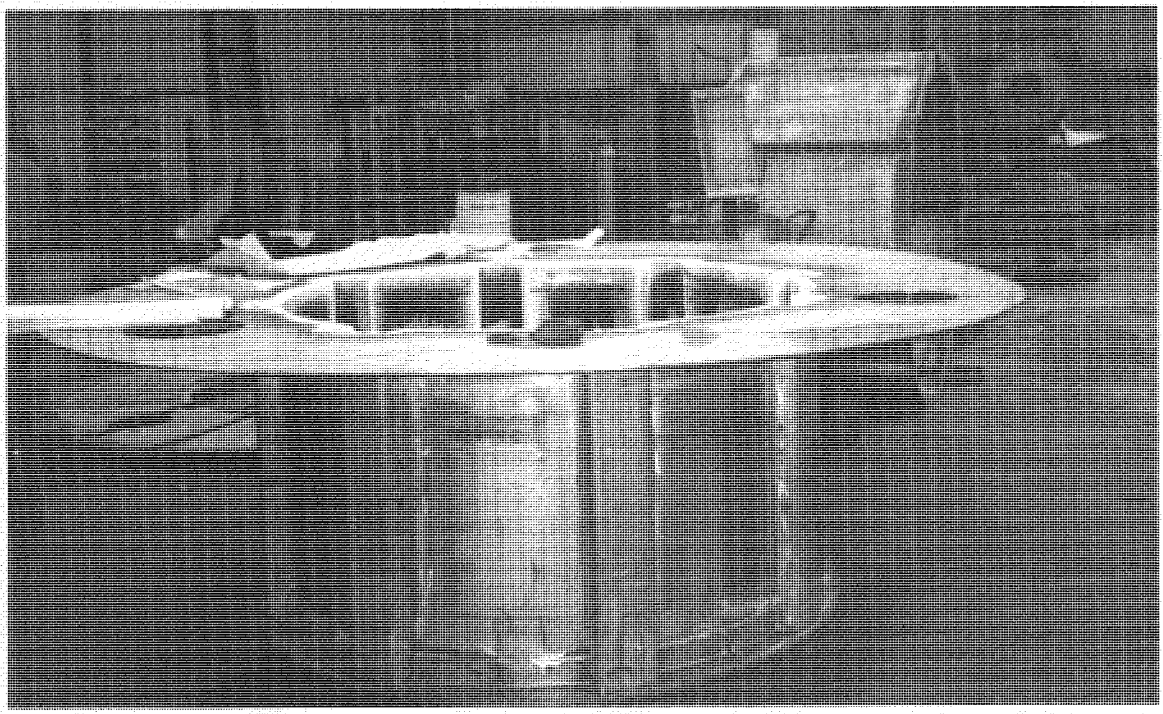


Figure 2-19. Preparing for lead pour into the cask body.



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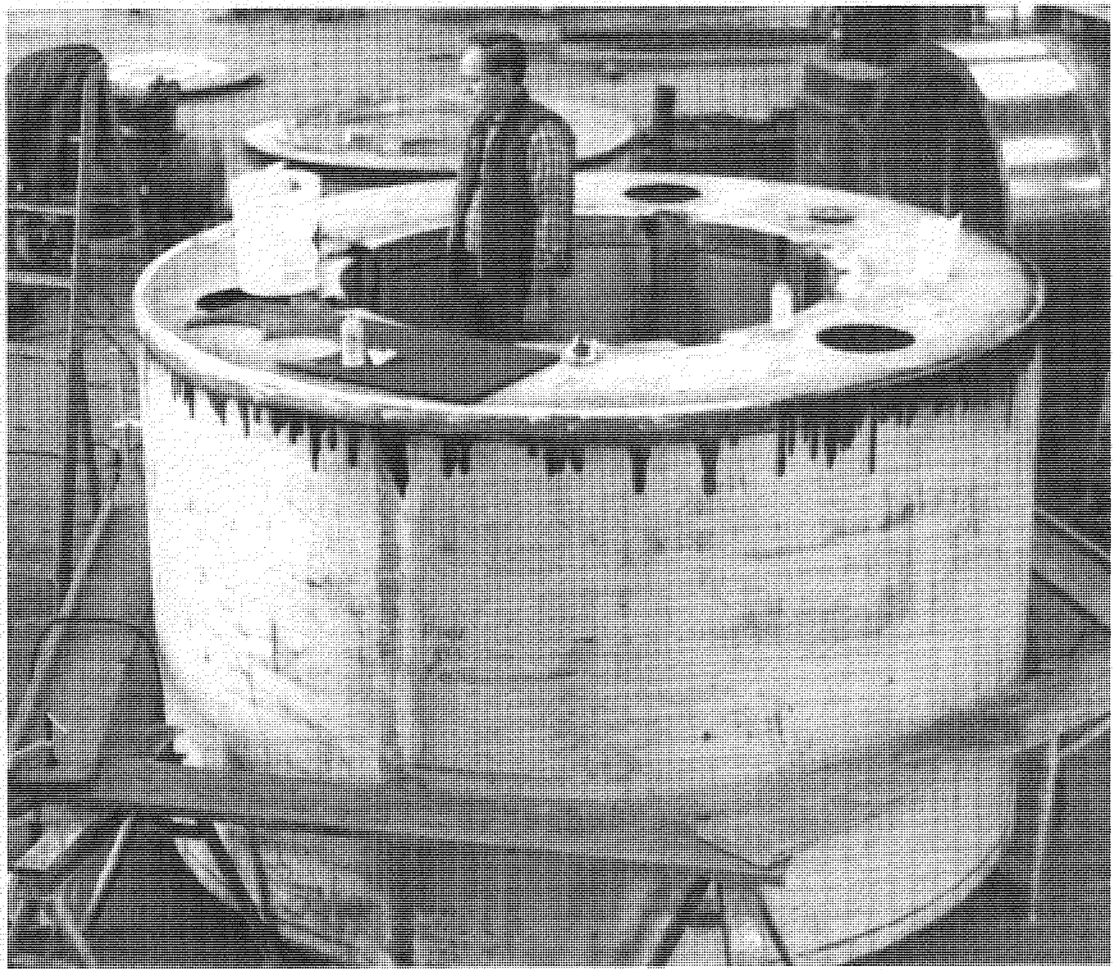

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Figure 2-20. Fabrication of overpacks.

essential to minimize rework, additional costs, and schedular delays. Program control specialists performed independent scheduling activities to review adequacy of resources and identification of critical path issues.

Collectively, the strong management of the fabrication effort by NuPac, the quality of the work by the subcontractors, and the oversight by EG&G Idaho resulted in delivery of the first cask on the required date of December 15, 1985. This was a notable accomplishment, especially since a number of activities were added to NuPac's scope during the process. These were major additions, including the one-quarter-scale cask drop program, the design and fabrication of the cask's auxiliary handling equipment, and preparations for an integrated test of the TMI-2 site cask loading equipment, as described in Section 2.6.5. An early picture of a cask on its railcar as delivered to TMI is shown in Figure 2-21.

The first cask was delivered to the INEL in early 1986 for an extensive cold (nonradioactive) test of the cask handling operations at CFA and the TAN Hot Shop. The second cask was similarly delivered to TMI-2 in March 1986 following a cold test at DOE's Hanford Site to ensure that the separate pieces of the TMI-2 cask loading equipment were integrated into a single system that performed as required. A third cask, as discussed in Section 3.2.2, was placed in service in November of 1987. This cask was leased by GPU Nuclear from NuPac. A quality overview for fabrication of the third cask was performed for GPU Nuclear by EG&G Idaho on a cost reimbursable basis.

2.5.5.1 NRC Fabrication Audit. NRC conducted an inspection of the implementation of NuPac's QA program in their Federal Way,

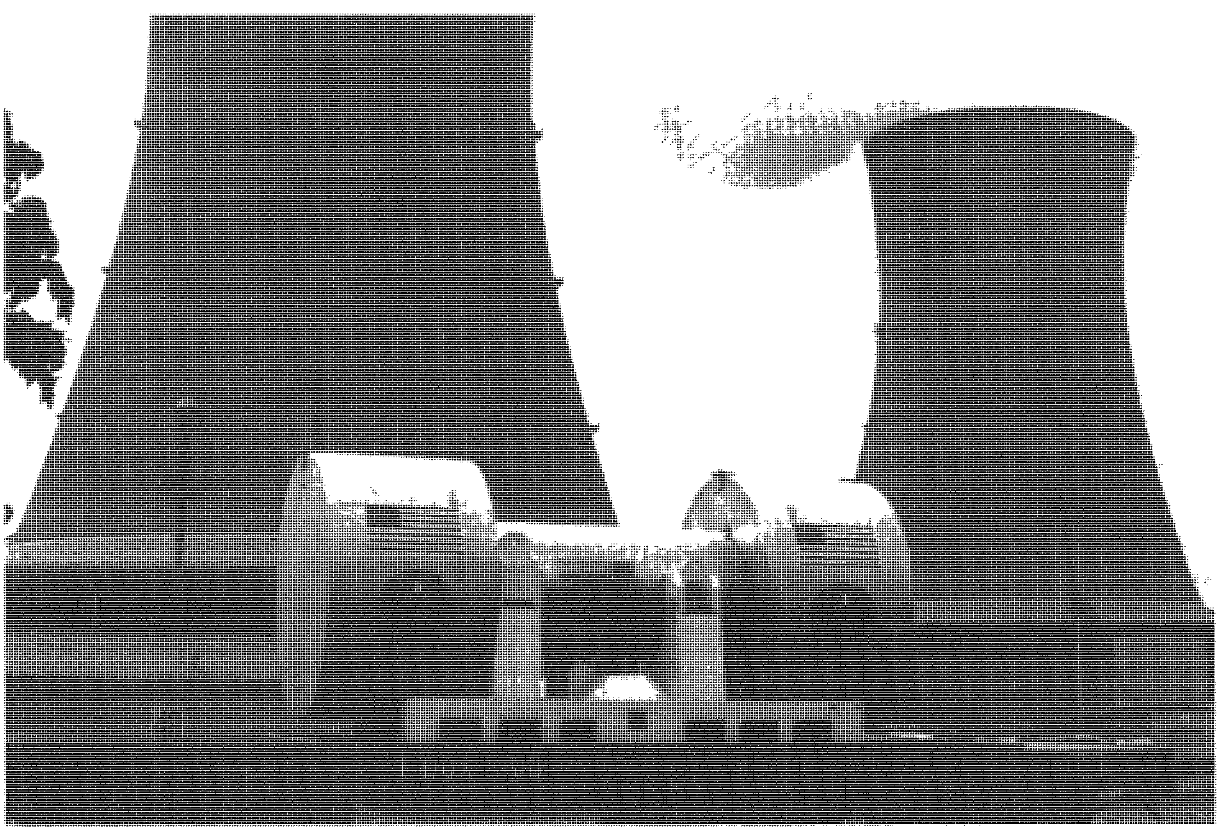

Figure 2-21. NuPac 125-B rail cask at TMI.

Washington, offices on May 5 to 8, 1986. The audit was part of a newly initiated NRC program of at-the-vendor inspections to check the performance of cask manufacturers under the QA requirements of 10 CFR 71. Several NRC inspectors were involved and focused on nondestructive testing records along with limited review of overall QA records for the NuPac 125-B cask.

During the inspection, NRC found that the implementation of NuPac's QA program was overall very good, but failed to meet certain NRC requirements and had weaknesses in the areas of personnel qualification, procurement, and nonconforming material. NRC further identified unresolved items concerning nondestructive tests required to be performed during fabrication of the NuPac 125-B casks.

At a meeting with NRC in their Bethesda, Maryland, offices on June 12, 1986, and in a subsequent inspection of NuPac's program in Federal Way, Washington, on June 21–26, 1986, NRC closed out all open items identified during the initial audit with the exception of one item. The unresolved item was the interpretation of a 1/4-in. long indication on a radiograph of the longitudinal weld of the outer shell of the second NuPac 125-B cask.

A meeting was then held with NRC in their Silver Spring, Maryland, offices on July 8, 1986, to discuss the weld radiograph and potential resolution. NuPac explained that the indication was due to a slag inclusion and was acceptable under the requirements specified in the cask SAR and used to fabricate the cask (i.e., ASME B&PV Code Section NB-5000). The NRC inspection team member, while at NuPac, had interpreted the indication as a potential lack of penetration, which would not have been acceptable under the ASME Code requirements. Potential resolutions that were discussed included use of an enhanced inspection technique to re-examine the weld, two possible methods for repair of the weld, and analysis of the weld to demonstrate that presence of an unacceptable flaw would not affect cask safety performance under accident conditions.

NRC undertook an independent review of the radiograph in question in a meeting held on July 15, 1986. A team of experts, including the NRC inspector identifying the potential concern at NuPac, were allowed to study the radiograph and confer. The decision reached was that the original interpretation of the radiograph by NuPac's shell fabricator was correct (slag inclusion in the weld). This meant that since the slag was acceptable per the criteria in the ASME Code, the cask met all fabrication-related requirements. The findings from NRC's audit of NuPac's fabrication of the 125-B casks were thus all closed, allowing the use of the casks.

2.6 TMI-2 Site Preparations

GPU Nuclear had many major tasks to perform to prepare the TMI-2 site facilities, personnel, and documentation for loading of casks with core debris canisters. Throughout these efforts, GPU Nuclear coordinated closely with EG&G Idaho and the other organizations involved in the core debris shipping program.

In May 1985, Bechtel initiated the development of a TMI-2 Fuel Shipping Integrated Punch List, delineating work activities and associated schedules required to support the start of shipping. Meetings were held once every two weeks to determine the status of problems and to expedite resolutions. The punch list meetings were chaired by Bechtel for GPU Nuclear with EG&G Idaho's and NRC's invited participation. The punch list approach was effective in tracking and resolving facility-related details during the approximately one-year period before the first shipment.

2.6.1 Cask Loading Process. TMI-2 site facility preparations included determining the most cost-effective method for cask loading, procuring equipment for the cask loading process, testing the equipment before installation in the contaminated work zones in the TMI FHB, modifications to the FHB to accept the equipment, installation of the equipment, and checkout before use. These activities were accomplished in an integrated manner with the many other tasks underway at the time as part of the TMI-2 cleanup.[32]

Determining the most cost-effective method for cask loading was discussed previously in Section 2.4 since GPU Nuclear's studies were an integral part of cask procurement. The dry-loading process using a rail cask was recognized in February 1984 to have more advantages than truck casks. By July 1984, the process had been developed to the point where conceptual designs for equipment were completed.

The sequence for loading at TMI-2 was initiated by arrival of an empty cask at the site. After a receipt inspection and health physics survey, the environmental cover and two overpacks were removed from the cask outside of the FHB truck bay. The railcar with cask was pushed part of the way into the truck bay, but the first set of wheels were stopped outside of the exclusion zone in the truck bay (area above the basement where TMI-1 redundant safety-related equipment is installed). This positioning placed the railcar under both the jib crane support platform and cask unloading station (CUS), as shown in Figure 2-22. The figure shows the four screw jacks on the CUS connected to the cask transport skid. The screw jacks lifted the cask and skid from the railcar, allowing the

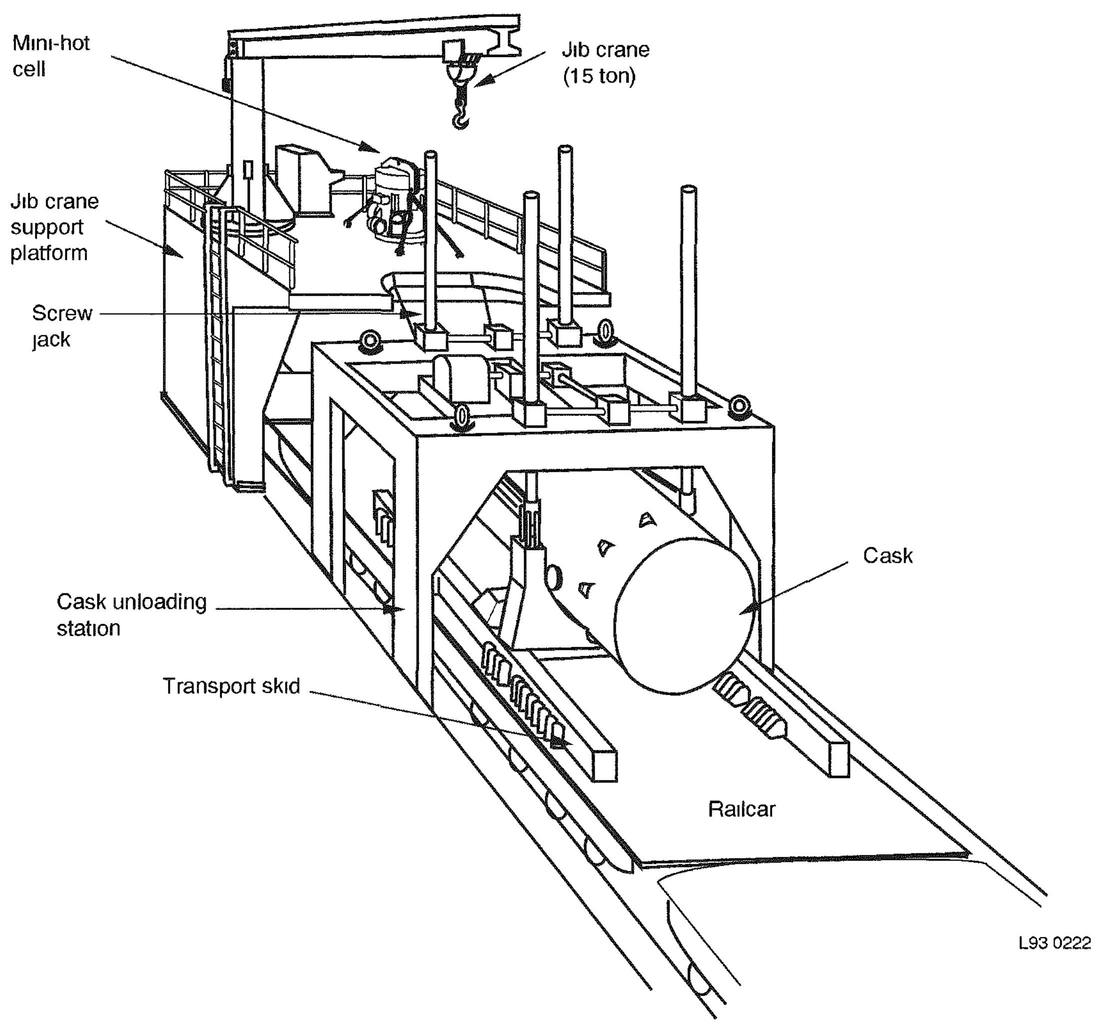

Figure 2-22. Cask unloading station used to remove a NuPac 125-B cask from a railcar.

railcar to be removed from under the skid. The jacks then lowered the skid and cask to the floor. An overhead crane lifted the CUS up and away from the cask for storage until after cask loading.

A cask hydraulic lift assembly (CHLA) was then attached to the skid, and hydraulic cylinders were used in conjunction with a cask lifting saddle, which worked against trunnions at the top end of the cask, to rotate the cask from horizontal to vertical. The hydraulic cylinders were sized and tested such that each, individually, could perform the needed cask rotation (from a single failure safety standpoint related to failure of a cylinder). The lifting saddle on the vertical cask was attached to the jib crane support platform and, as shown in Figure 2-23, a work platform was installed around the cask body for access to the lid end of the cask. After the lid of the OCV and then the ICV were removed using a lid-lifting tool attached to a crane, the interior of the cask was inspected and, when required, decontaminated. Repairs, such as to internal impact limiters, and some cask maintenance activities were also performed at this time.

Specialized equipment was used for cask dry loading. As shown in Figure 2-23, equipment for dry loading of a cask included a cask loading collar, mini-hot cell, and fuel transfer cask. Figure 2-24 is a photograph of cask loading operations at TMI.

The shipping cask loading collar (SCLC) was an interface between the shipping cask and the fuel transfer cask during cask loading. The SCLC consisted of two primary components, the load collar and the auxiliary shield. The load collar included an alignment ring and rotating bearing assembly pinned to the ICV. The auxiliary shield rested on the load collar while surrounding the top surface of the OCV flange. The shield had an integral motor-driven sliding door assembly. The function of the SCLC was to rotate such that the door opened above each of the six outer positions for loading a canister into the cask ICV. The SCLC also had a center port used to load the center canister. The SCLC thus provided shielding for personnel loading the canisters into the shipping cask.

With the SCLC in place, the cask loading sequence proceeded as follows. The mini-hot cell (MHC) was placed above the door on the SCLC, the SCLC's door was opened, and a grapple was lowered into an empty cask to pull an ICV shield plug up into the MHC cavity. Figure 2-25 shows an outer position shield plug removed from the ICV and in the MHC cavity. After the SCLC's door was reclosed, the jib crane then removed the MHC from above the SCLC.

While the MHC was removing the initial shield plug, the fuel transfer cask (FTC) was sent to the FTC loading station in the "A" fuel pool of TMI-2. The FTC is a lead-shielded, bottom-loading cask capable of raising and lowering a single canister into its cavity for enclosed transfer in the TMI-2 FHB. The FTC loading station was both a platform on which the FTC was placed and a decontamination system for external decontamination of canisters.

A fundamental advantage of using the FTC for the dry loading process was that neither the FTC nor the shipping cask ever entered the contaminated pool water and so did not require time-consuming decontamination typical of wet loaded casks. In the dry loading process, a canister that had been dewatered, monitored for water inleakage, tested for net gas generation, and weighed was placed into a storage rack under the FTC loading station. The FTC was placed on the platform and aligned with the canister. A grapple was lowered from the FTC down into the water into the socket on the canister and engaged. As a canister was lifted up out of the water into the FTC, the exterior surface of the canister was sprayed with borated demineralized water for decontamination. When a canister was completely in the FTC cavity and allowed to drip dry for at least a couple of minutes, a sliding shield door at the bottom of the FTC was closed.

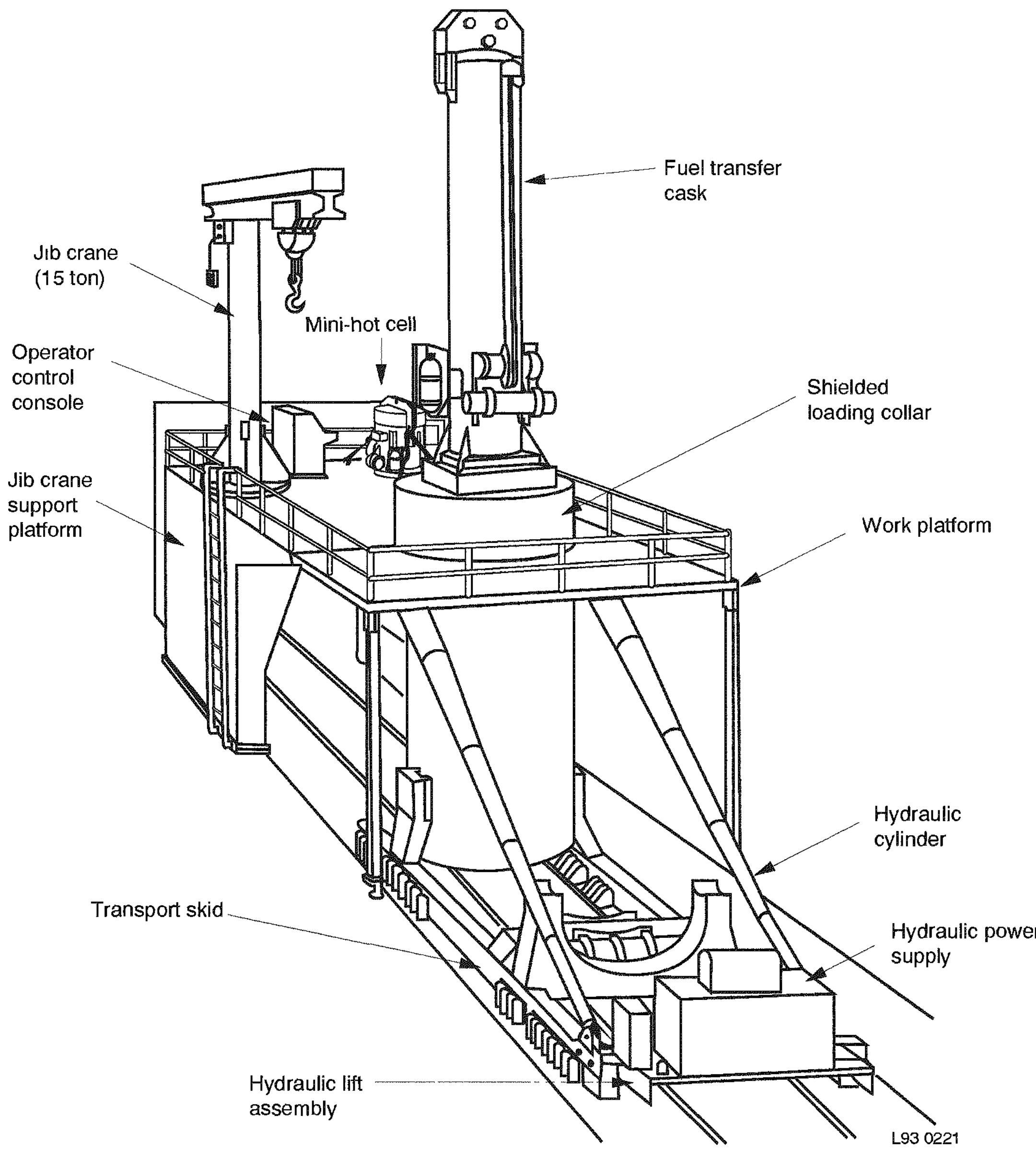

Figure 2-23. Equipment used in dry loading the NuPac 125-B cask with core debris canisters at TMI-2.

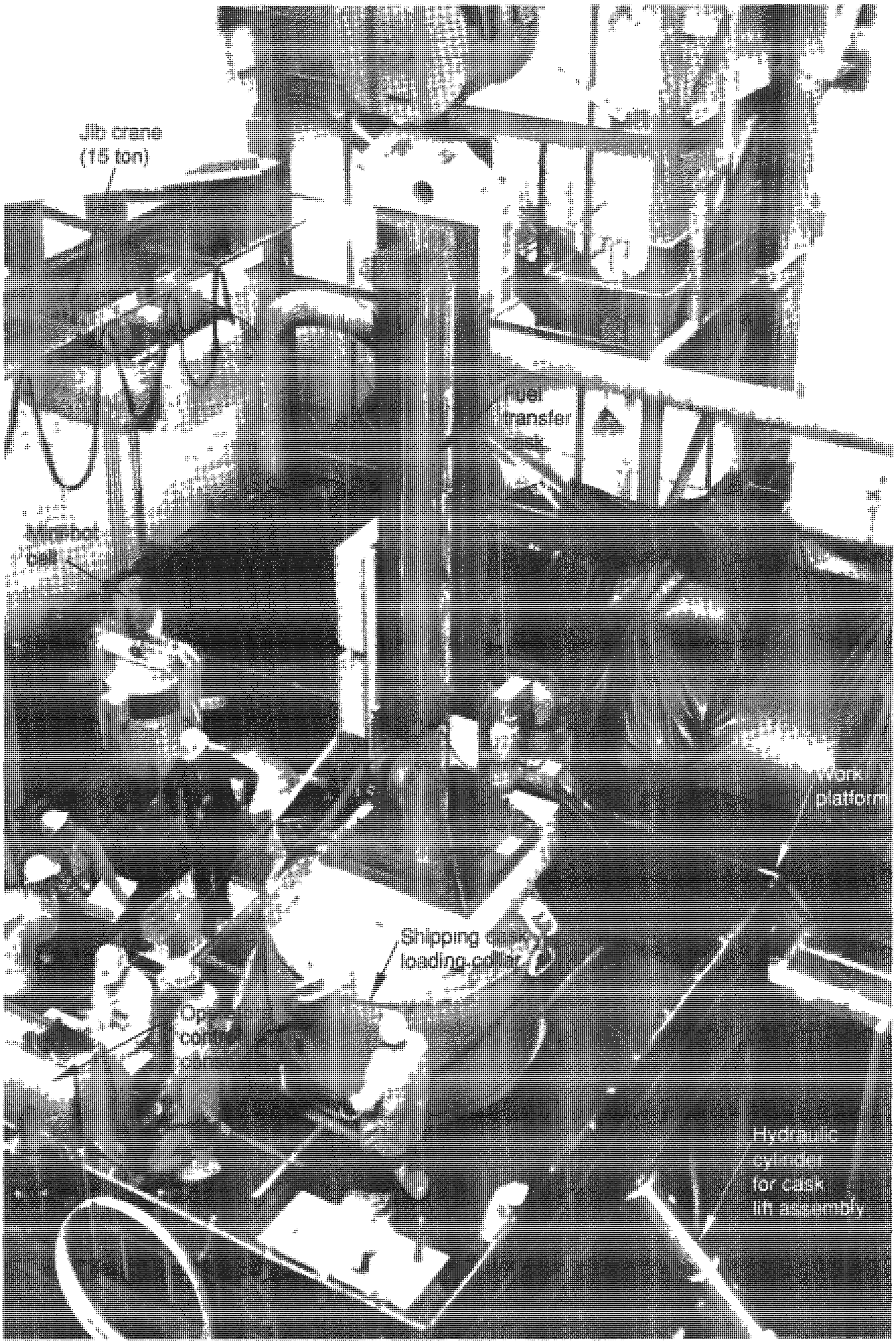

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Figure 2-24. Cask loading operations at TMI-2.

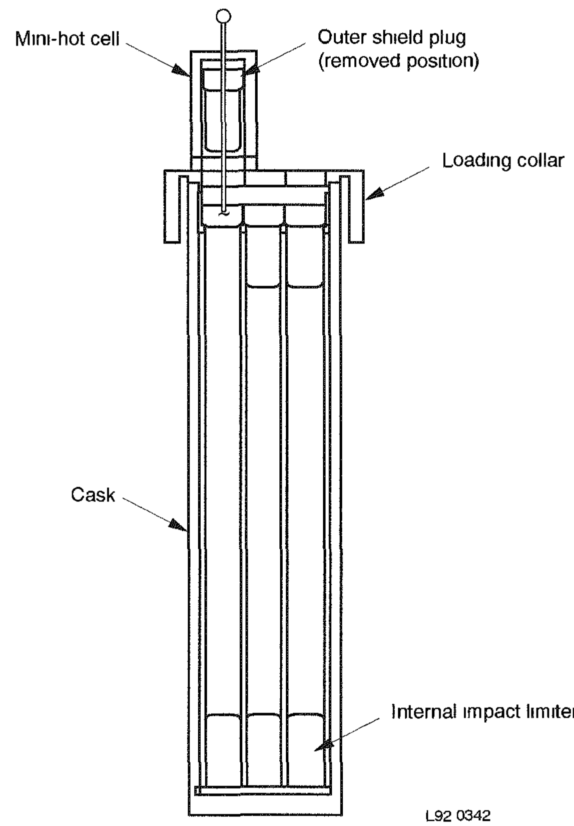

Figure 2-25. Shield plug being withdrawn from an empty cask before loading a canister.

An overhead crane lifted the FTC with the canister up over the edge of the pool, moved it along an assigned load path at the top of the pool, and lowered it on to the top of the door on the SCLC. After shield doors on the FTC and SCLC were opened, the canister was lowered into a cask as shown in Figure 2-26. The MHC process was then reversed, with the MHC used to lower the previously removed plug down into the ICV above the just-loaded canister. The MHC thereby provided a means to reinstall an ICV shield plug into the ICV remotely and prevented creating a path for direct (unshielded) exposure to workers from the canister just placed in a cask.

These core debris canister transfer steps using the SCLC, MHC, and FTC were then repeated for six other canisters to completely load a cask. The next step in preparing a cask for shipment was to remove the SCLC (load collar and auxiliary shield) and install the ICV lid. Note that the ICV shield plugs performed their function after removal of the SCLC. The plugs prevented direct (unshielded) radiation exposures from the canisters in the ICV and were sized thick enough to lower the dose rates to levels that allowed "hands-on" installation of the ICV lid. The seals on the ICV were then leakage-rate tested, and the OCV lid was installed and tested.

With the cask resealed, the work platform was removed and the loaded cask was rotated from vertical back down to horizontal on the transfer skid using the CHLA. The CHLA was removed and the CUS was replaced over the cask and skid. The CUS was reattached to the skid and lifted the cask and skid up to allow replacement of the railcar below the skid. After lowering the skid with the cask onto the railcar deck and attaching the skid to the railcar, the CUS was disconnected. The railcar and cask were then removed from the truck bay for installation of overpacks and an environmental cover.

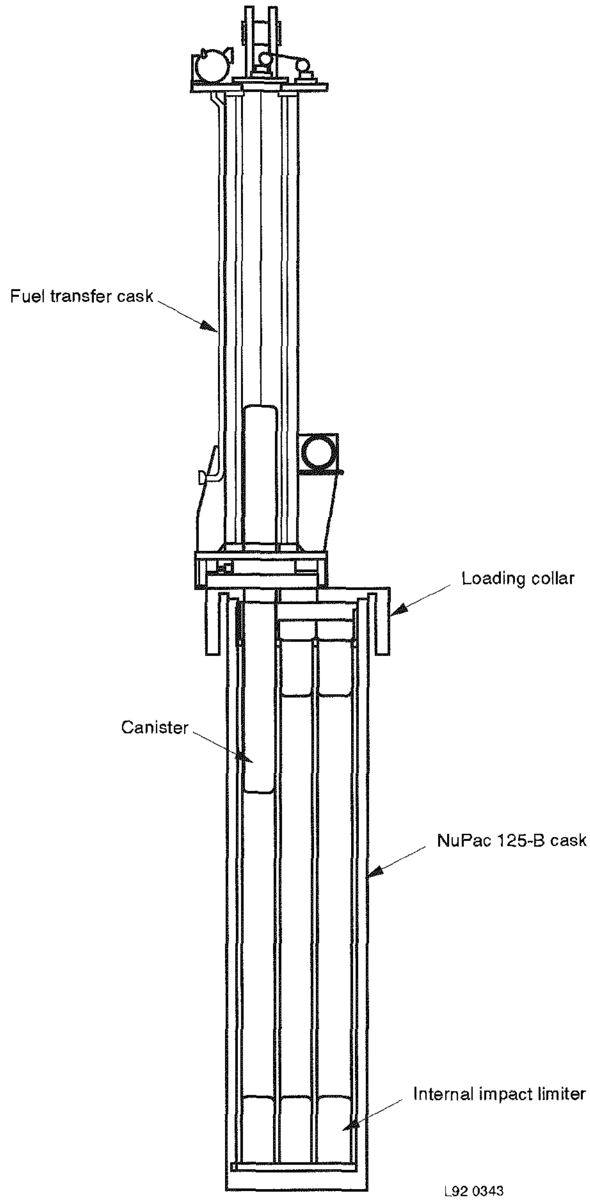

Figure 2-26. Canister being lowered into a cask.

2.6.2 TMI-2 Facility Modifications. GPU Nuclear made several modifications to the TMI-2 facility in preparation for loading a NuPac 125-B cask.[33] The cask handling and loading processes, and therefore the modifications, were complicated by the need to perform the operations in the truck bay of the FHB at the TMI site. The FHB is shared by both units. The complications for the TMI-2 core debris shipping program resulted from a need to perform all activities on a non-interference basis with Unit 1, which by the beginning of the shipping campaign had been restarted and was an operating power reactor. Close coordination was required to modify the as-built layout of the facility for the shipments and to perform subsequent cask operations smoothly. Some of the requirements imposed on all TMI-2 activities included:

- No area on the TMI-1 side of the truck bay could become a radiation work area (dose rates exceeding 2.5 mR/hr) as a result of a TMI-2 activity

- Physical separation between units (fences) were maintained for security reasons

- The most conservative approach to licensing requirements was always taken (i.e., the restraints for the TMI-2 cask handling and support equipment were designed to meet the Unit 1 requirements for withstanding seismic loads because the Unit 1 requirements were more restrictive than the Unit 2 requirements)

- An exclusion zone was designated in the truck bay, into which loads were not permitted because of Unit 1 redundant safety cables in the basement.

To achieve the close coordination needed among TMI-2 organizations and with Unit 1, GPU Nuclear formed a fuel shipping group with members from Unit 1 and TMI-2 Engineering, Operations, Maintenance, Radwaste Support, Safety, Security, Radiological Controls, Technical Planning, Licensing, and Program Controls. Representatives from Bechtel's Design Engineering organization, EG&G Idaho, and NRC also attended the fuel shipping group's weekly meetings.

The group was successful in identifying all on-site regulatory requirements and operating restrictions that applied to performing the core debris shipments. The evaluation of these limitations was the basis for the functional design requirements for the cask handling and loading systems. The group also determined the personnel requirements for loading operations consistent with planned shipping schedules.

The principal modifications to the "A" fuel storage pool were the additions of two work platforms built just above the pool's water level. One platform was used to dewater and inert each canister after removal from the reactor building, repair canisters if necessary, and obtain gas samples to monitor gas generation over time to verify the absence of a buildup of a mixture of hydrogen and oxygen gases from radiolysis. The other platform was the FTC loading station, where canisters were decontaminated while being lifted into the FTC.

There were also several modifications made to the truck bay. The most significant changes were to accommodate the cask handling equipment. Anchor plates were installed in the floor for the skid tiedown brackets. Sockets were installed in the floor to properly position the CUS with respect to the floor plates. Foundations were installed for the jib crane support platform. The seismic requirements necessary for the cask support equipment required the installations for the skid anchor plates and jib crane support platform to connect to the building structure. This required removal of some concrete to reach the steel members.

In addition, stands were designed, fabricated, and installed for temporary storage of the cask's outer and inner vessel lids. The drains from the truck bay were rerouted from the TMI-1 waste processing systems to the TMI-2 radwaste systems. A rail stop was added to the rails in the floor of the truck bay. The FHB overhead crane was analyzed using a failure modes and effects analysis, thoroughly inspected, and had safety-related upgrades made. Miscellaneous modifications were made to the utility systems.

Besides the modifications in the truck bay, there was a need to inspect and replace some of the ties in the railroad track from the front gate at the TMI site to the FHB door. Also, a section of rail used as a removable rail moat bridge was fabricated to span the gap in the rails for the FHB missile door, thus connecting the track in the yard with the track in the truck bay.

2.6.3 Cask Loading Equipment Modifications. GPU Nuclear was responsible for providing the equipment for dry loading. Bechtel managed the preparation of the design specifications and procurement of the SCLC, MHC, FTC, FTC loading station, cask jib crane support platform, work platform, and jib crane from NuPac and other suppliers. The designs met many requirements to accomplish the loading process without causing unacceptable risk to the health and safety of the public.

The major concern with cask loading activities was handling of the heavy loads in the FHB. TMI-2 had a heavy load handling program approved by NRC that was expanded to allow for dry loading of a shipping cask. The program complied with the requirements of NUREG-0612 for safe load paths; use of approved procedures; trained and qualified operators; special and standard lifting devices; crane design; and crane inspection, testing, and maintenance.[34]

Heavy-load drop concerns caused a major change in the dry loading approach during development of the cask handling equipment. From mid-1984 until January 1985, the dry loading concept had proceeded based on using the FHB overhead crane for rotating of the shipping cask from horizontal to vertical and back down to horizontal. In this concept, the cask would not have been removed from the railcar. The railcar would have been stabilized by jacks for cask rotation. A lifting yoke would have been attached to a set of trunnions at the upper end of the cask and a lift by the crane used to rotate the cask to vertical. During lowering to horizontal, the crane would have controlled the cask's rotation. Accident analyses identified that failure of the FHB crane during cask rotation would have resulted in a slapdown of the cask onto the railcar. The potential damage to the truck bay and FHB equipment in the basement was unacceptable to GPU Nuclear.

The initial consideration was to provide hydraulic snubbers between the cask and skid to prevent an uncontrolled slapdown of the cask. Further discussions and evaluations showed that the CHLA could be used instead of the crane and therefore eliminated potential failure of the FHB crane during this operation. However, several complications arose with the division of responsibilities between GPU Nuclear and EG&G Idaho for the handling equipment.

The transport skid was clearly in EG&G Idaho's scope, but as designed, required modification to accommodate the CHLA. Also, a lifting yoke had been included in EG&G Idaho's scope to provide for use at TMI-2 with the casks, but was not needed with use of the CHLA. Since the CHLA was performing the function of the FHB crane, GPU Nuclear was responsible for providing the CHLA. However, since the design of the CHLA required close integration with redesign of the skid, EG&G Idaho agreed to include procurement of the CHLA under EG&G Idaho's cask procurement contract.

At the same time that the concern with slapdown of a cask from potential crane failure was identified and resolved, the details for potential modifications of the truck bay to accommodate railcars were being considered. For railcars longer than approximately 20 m (65 ft), a structure called the environmental barrier needed to be modified to allow a railcar to enter far enough into the building for uprighting a cask.

As an alternative to significantly modifying the barrier, the concept of removing a cask and skid from a railcar was considered. Again, heavy-load drop concerns (weight of a loaded cask and skid versus the lifting capacity of the FHB crane) prompted GPU Nuclear to consider means other than the overhead crane to lift and lower a cask. The CUS was the preferred solution but again required redesign of the skid for attachment of the CUS to the skid. EG&G Idaho agreed to have the CUS included in the scope for the cask supply contract but reimbursed by GPU Nuclear. This allowed all cask lifting, rotating, and transport equipment to be designed, fabricated, and tested under a single contract guided by a set of functional requirements specified by GPU Nuclear.

2.6.4 Cask Loading Equipment General Design Criteria. The design process used by GPU Nuclear and NuPac in developing the dry cask loading equipment included some general requirements applicable to all components.[35] These guidelines included:

- All lifting and handling equipment was designed to NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants*,[34] and ANSI N14.6, "American National Standard for Special Lifting Devices for Nuclear Material Shipping Containers Weighing 10,000 Pounds or More"[36]

- System components were designed with redundant safety and operating features to accommodate "off-normal" operating conditions

- System equipment was designed to fail in a safe manner assuming a failure would occur (fail safe)

- Equipment included lead shielding to reduce personnel radiation doses

- System components were designed as modules to facilitate installation and maintenance

- Equipment materials and coatings were selected to facilitate decontamination of radioactive materials

- Equipment to support and stabilize the cask was designed to withstand the safe shutdown earthquake seismic requirements.

The use of these general requirements and several TMI-2 facility-specific requirements ensured that the equipment provided by NuPac was designed to meet the needs of GPU Nuclear for dry cask loading in the TMI-2 truck bay.

2.6.5 Cask Loading Equipment Testing. GPU Nuclear, EG&G Idaho, DOE, and NuPac were in general agreement that the many pieces of equipment that constituted the system for dry loading needed to be tested before use in actual cask loading operations at TMI-2. While NuPac, as the system designer, was responsible for a completely integrated system, the hardware was being supplied to GPU Nuclear under separate contracts to Bechtel and EG&G Idaho. Likewise, no single fabricator was used by NuPac to build all components of the system.

Many of the same contractors identified in Section 2.5.5 on cask fabrication were also used by NuPac for cask handling and loading equipment. Fabrication activities were performed on an expedited basis consistent with meeting the schedule for early delivery of the casks. Each component was functionally tested individually at the time of acceptance testing at the manufacturer's shop. However, the use of multiple manufacturers left integration of the overall system to be accomplished separately.

Several possible options for testing were evaluated, including use of facilities in the Seattle, Washington, and Harrisburg, Pennsylvania, areas. The selected approach was to perform an integrated test of the installation, assembly, operation, and disassembly of the equipment at a DOE-operated facility, which permitted the needed integrational checkout of the equipment and at the same time allowed GPU Nuclear personnel access to the test for early training on the equipment. The test was held at the Maintenance and Support Facility (MASF) at the Fast Flux Test Facility near Richland, Washington. Operated as part of the DOE Hanford Engineering Development Laboratory (HEDL) by Westinghouse Hanford Company (WHC), the activity allowed NuPac and GPU Nuclear to perform a complete integrated test of the cask loading system. As a support contractor to DOE's TMI-2 program for other cleanup-related activities, WHC was funded by DOE to assist in the cold (nonradioactive) demonstration of the dry cask loading system.

Known as the HEDL Integrated Test, the second cask manufactured and all cask loading equipment were delivered to the High Bay at MASF by late January 1986. Also, special equipment was fabricated, such as large steel boxes to simulate FHB configuration and to support the jib crane support platform. The objectives met by the integrated test were as follows:

- Confirmed that each piece of equipment performed as designed and that all design criteria were met
- Verified that each piece of equipment interfaced properly with other system components, by performing the operating sequence
- Provided a means of verifying and revising operating and maintenance procedures
- Performed all limiting case startup and test functions
- Verified the ability to maintain equipment as specified in the procedures
- Verified installation sequence and instructions
- Obtained time estimates for equipment operation durations and baseline operating data
- Allowed GPU Nuclear operations and maintenance personnel to train for installation, calibration, operation, and maintenance of the equipment
- Provided video tapes of the operating sequence for training at TMI-2.

The integrated test was successful not only in achieving the objectives but in doing so away from TMI-2, where small anomalies in installation and checkout of the equipment would have been frustrating and much more costly to correct. Several necessary mechanical and electrical modifications and equipment improvements were uncovered by the integrated test. Changes were engineered and implemented within hours and days rather than days or weeks had the equipment been set up at TMI-2 initially.

The test enabled many TMI-2 operators to gain first-hand knowledge of the equipment's design and operation, including an understanding of the functional requirements by direct discussions with NuPac's design engineers. This transfer of information was very valuable to the straightforward installation and use of the equipment at TMI-2.

The integrated test lasted a month, including initial system assembly, testing, disassembly, and packing for the shipment to TMI-2. The cost-effectiveness of the integrated test was indicated by the fact that equipment went from receipt at TMI-2 to NRC approval for use in less than two months.

2.6.6 Cask Loading Safety Documentation. The safety documentation required to be written and approved before cask loading at TMI-2 was voluminous. Types of documents included unit work instructions (UWIs), standard operating procedures (SOPs), safety analysis/safety evaluation reports (SERs), technical evaluation reports (TERs), and system descriptions (SDs).[37] Each of these document types were required for cask loading. The SERs and TERs were submitted to the NRC for approval along with SDs for information. The documents were updated annually, or more frequently in some cases, when required. These documents became part of the NRC files under Docket No. 50-320.[38]

In general, the bases for the technical content of GPU Nuclear's documentation were provided by B&W for canister handling and by NuPac for cask loading equipment. For example, the cask's SAR included chapters on operations and maintenance requirements. NuPac elaborated on these requirements in an operations and maintenance (O&M) manual for the cask. NuPac similarly provided O&M manuals for the fuel transfer cask and other equipment in the cask loading system.

GPU Nuclear used the vendor data to prepare the safety evaluations and procedures submitted to NRC for approval to perform the operation. Appendix F lists many of the GPU Nuclear safety-related documents, procedures, and technical evaluations that are closely related to canister design, preparation of canisters for shipment, cask handling in the truck bay, and dry loading canisters into the cask. The listing includes a short description of the subject addressed in the document. Also included on the list are GPU Nuclear prepared technical bulletins, which were short summaries to quickly document and disseminate technical information gained during the cleanup. Several bulletins related to subjects of interest to the core debris shipping program are described in Appendix F.

2.7 INEL Site Preparations

Studies as to possible INEL handling and storage facilities for the TMI-2 core debris were ongoing at the INEL long before DOE's decision that the INEL should receive the debris. These studies provided necessary data to DOE in their decisionmaking process. The studies included evaluations of the construction of new storage facilities such as dry storage vaults or the use of existing facilities such as the TAN-607 Hot Shop and fuel storage pool. The possibility of processing the debris for removal of unburned fuel and stabilizing the resulting waste was also evaluated, either with a new facility or with use of processes at the Idaho Chemical Processing Plant. The studies required integrating the needs projected from the emerging core examination program (e.g., facility capability to open canisters and remove contents for examination) and facilities with capabilities to receive either truck or rail casks (since the decision regarding type of transport package had not been finalized at the time of these studies).

The TAN Hot Shop became the facility of choice to receive and store the core debris for reasons that included existing equipment, experience, and capabilities to handle and unload large casks at rates expected to be compatible with GPU Nuclear's projected defueling and shipping rates, the existence of integral hot cells that could support disassembly and removal of canister contents for examination, and available space in the TAN storage pool.

Once DOE decided that the INEL would receive the TMI-2 core debris, and the decision to use rail casks was made, a period of intense activity began between INEL programmatic personnel, TIO personnel, GPU Nuclear, GPU Nuclear's contractors, other DOE laboratory personnel, and various specialized support contractors. The thrust of this activity was to ensure that the proposed transport equipment, packaging, and canisters for the core debris would be compatible with the facilities and handling equipment at the INEL, either already existing or through modification and procurement. A host of issues was involved, including handling methodology and logistics, facility safety requirements, equipment functional requirements, personnel and training requirements, and acceptance criteria for the canisters of core debris.

An overview of the methodology that subsequently evolved to receive, transfer, and unload the rail casks, along with the methodology for storing the canisters of core debris, is provided below. Sections on the documentation and other preparations for the receipt and storage activity are also provided. Discussions of actual receipt and storage operations are found in Section 3.3.

2.7.1 Receiving and Unloading Process for the Rail Casks at the INEL. Union Pacific Railroad (UP) delivered the rail casks to the Scoville rail siding, near the southern border of the INEL, where they were picked up by the INEL locomotive and transferred to the INEL Central Facilities Area (CFA) (see Figure 2-27). Since no rail line transited INEL between CFA and TAN, a method for transferring the rail casks from CFA to TAN, a distance of approximately 50 km (30 mi), needed to be developed. The method used was a special truck transporter for the transport of each rail cask across the INEL. At CFA, the locomotive was used to position the railcar under an existing gantry crane, which was used to transfer the rail cask to the truck transporter (see Figures 2-28 and 2-29).

At TAN, the loaded transporter was backed into the Heavy Equipment Cleaning Facility

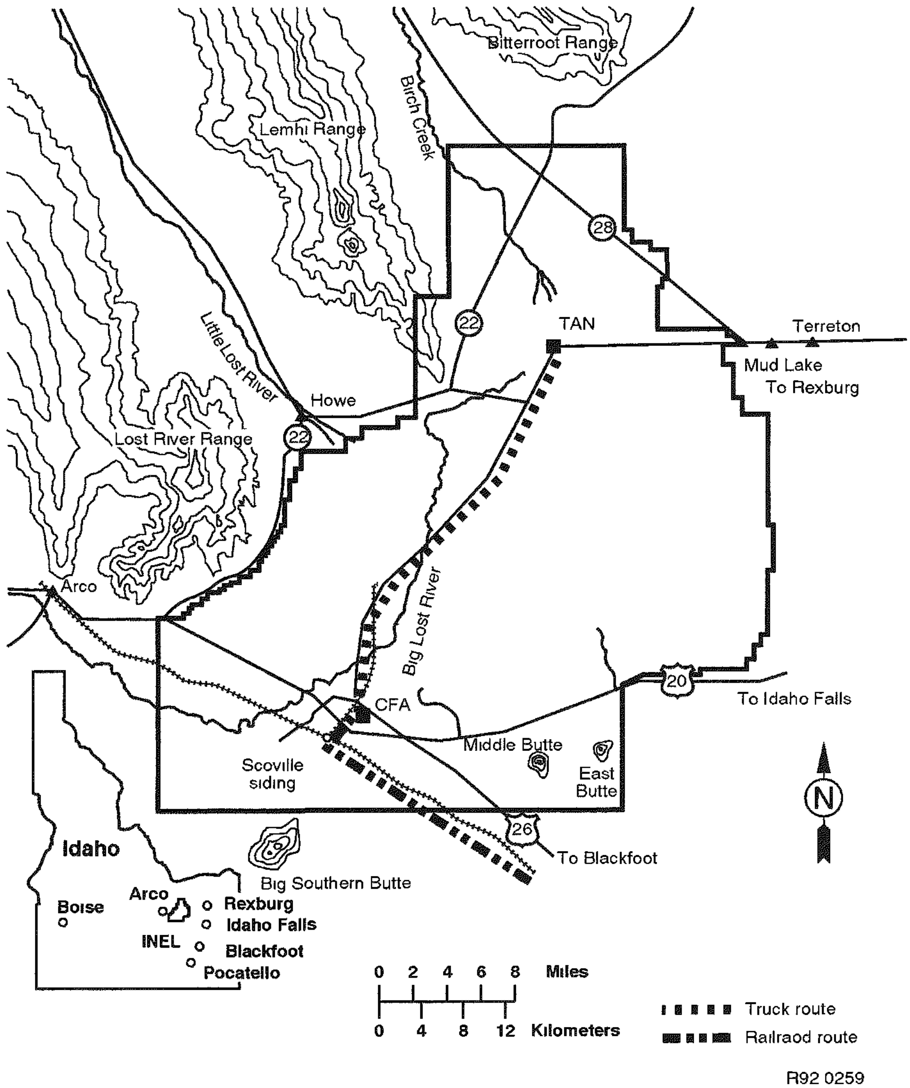

Figure 2-27. Route of a railcar and truck transporter carrying a NuPac 125-B rail cask at the INEL.

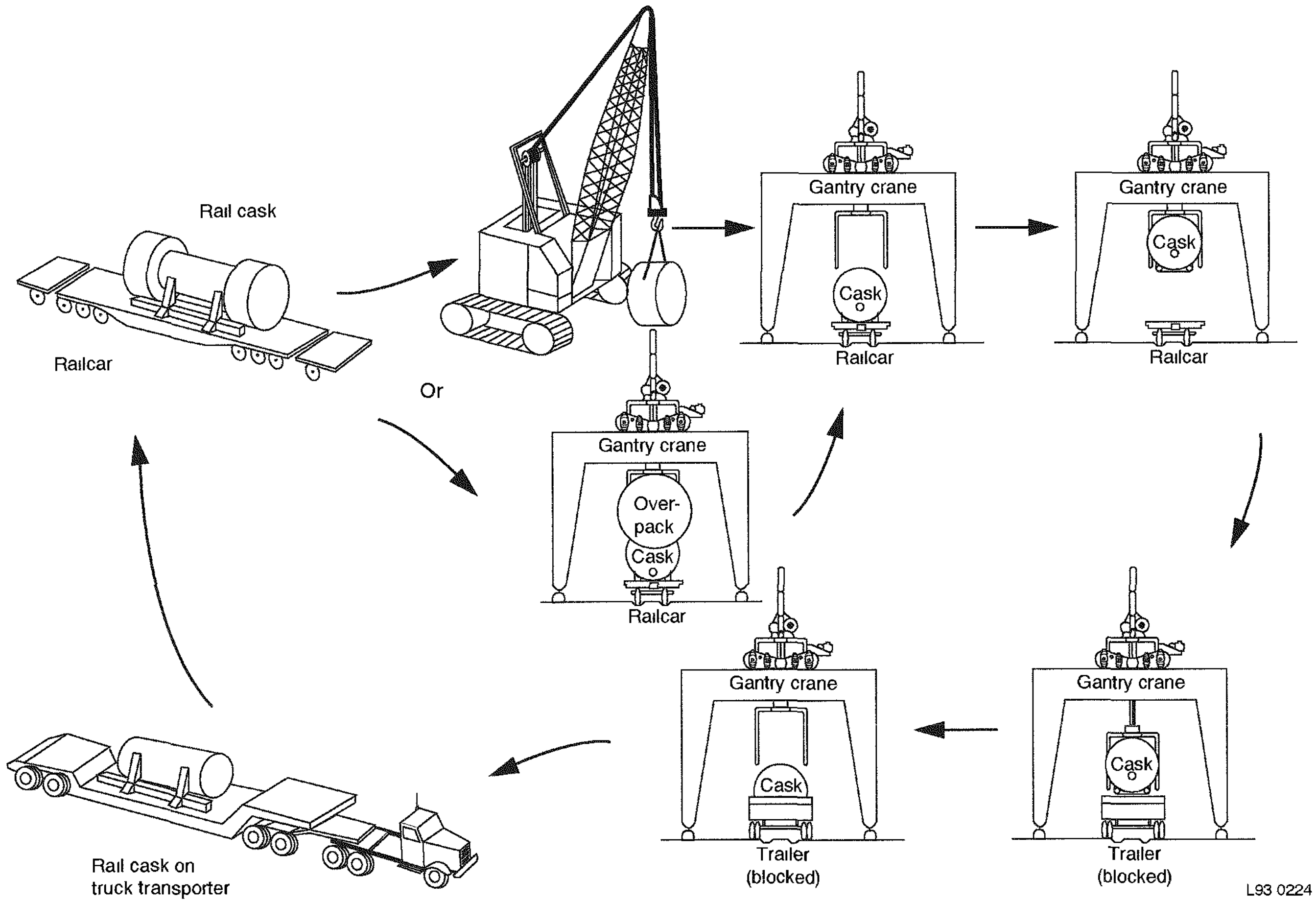

Figure 2-28. Schematic showing the sequence of events in transferring a NuPac 125-B rail cask from a railcar to the truck transporter.

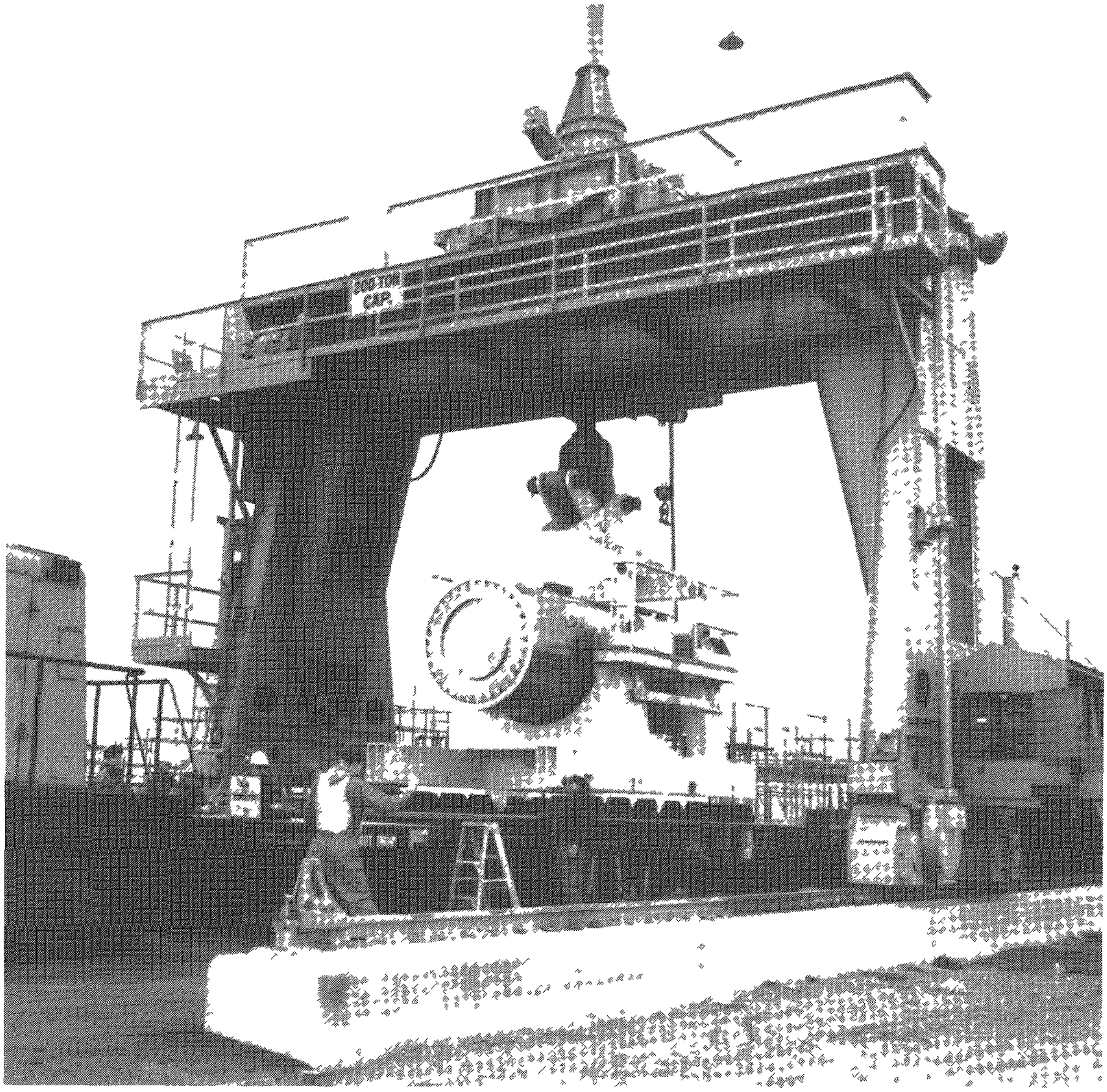

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Figure 2-29. At the INEL, the cask was transferred from the train to a truck transporter using the 200-ton gantry crane at CFA.

(HECF)[e]; both the cask and transporter were surveyed for external radiation and surface contamination. Dirt, snow, and ice were removed, if necessary. Mechanics then removed the four trunnion blocks from the transport skid and the shear plates from under the cask. With these preparations, the transporter with cask was ready for backing into the Hot Shop for unloading (see Figures 2-30 and 2-31).

The cask was uprighted from the transporter using an overhead crane and vertical lift fixture attached to the casks uppermost set of trunnions. In the lift, the cask rotated on the skid at the lower trunnions. After being raised to vertical, the cask was taken to the cask unloading stand for removal

e. The HECF was a facility upgrade added to the TAN facility part way through the shipping campaign; prior to the upgrade, many of the operations identified as being performed in the HECF were performed in the Hot Shop.

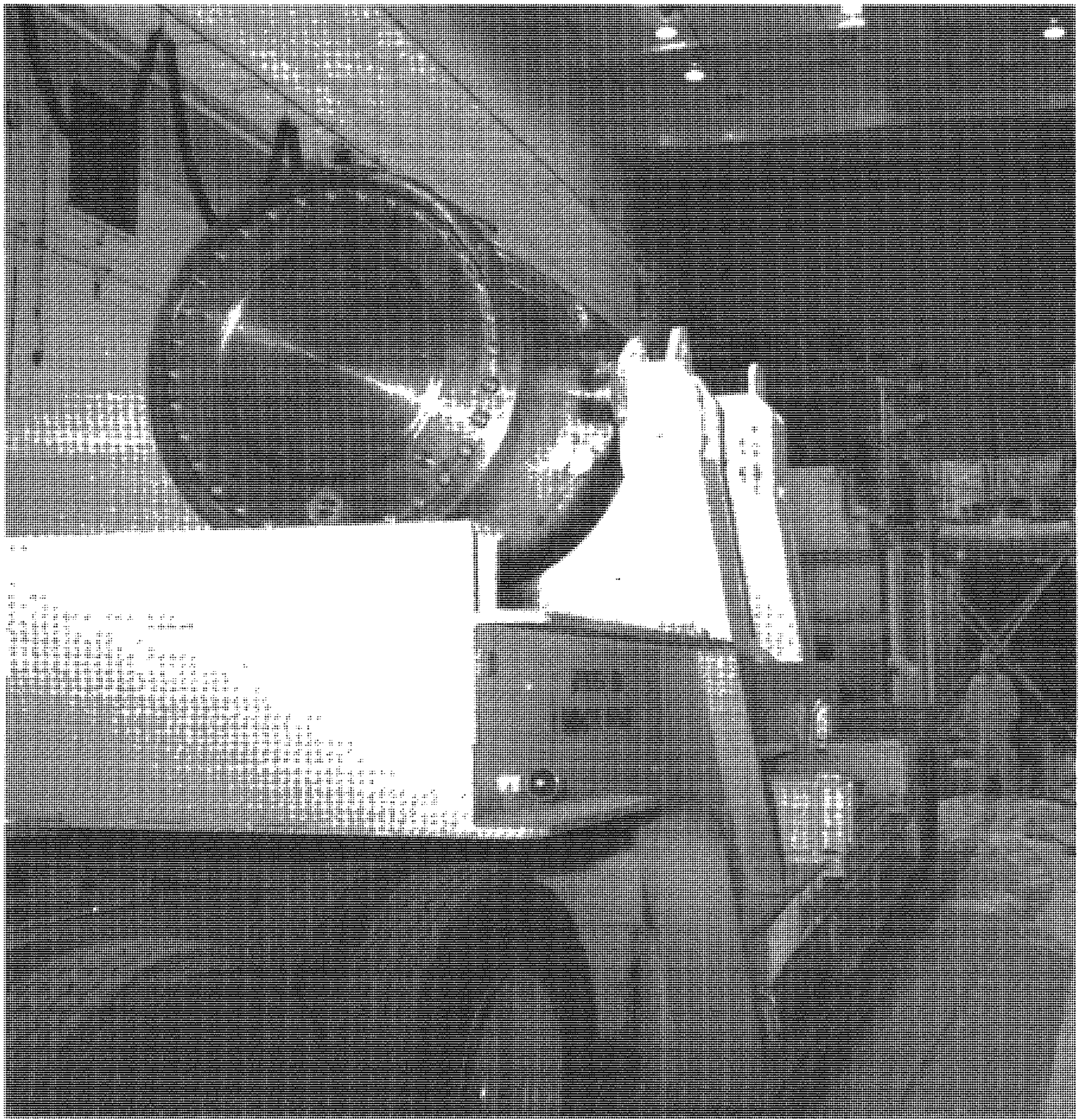

Figure 2-30. Cask entering the TAN Hot Shop.

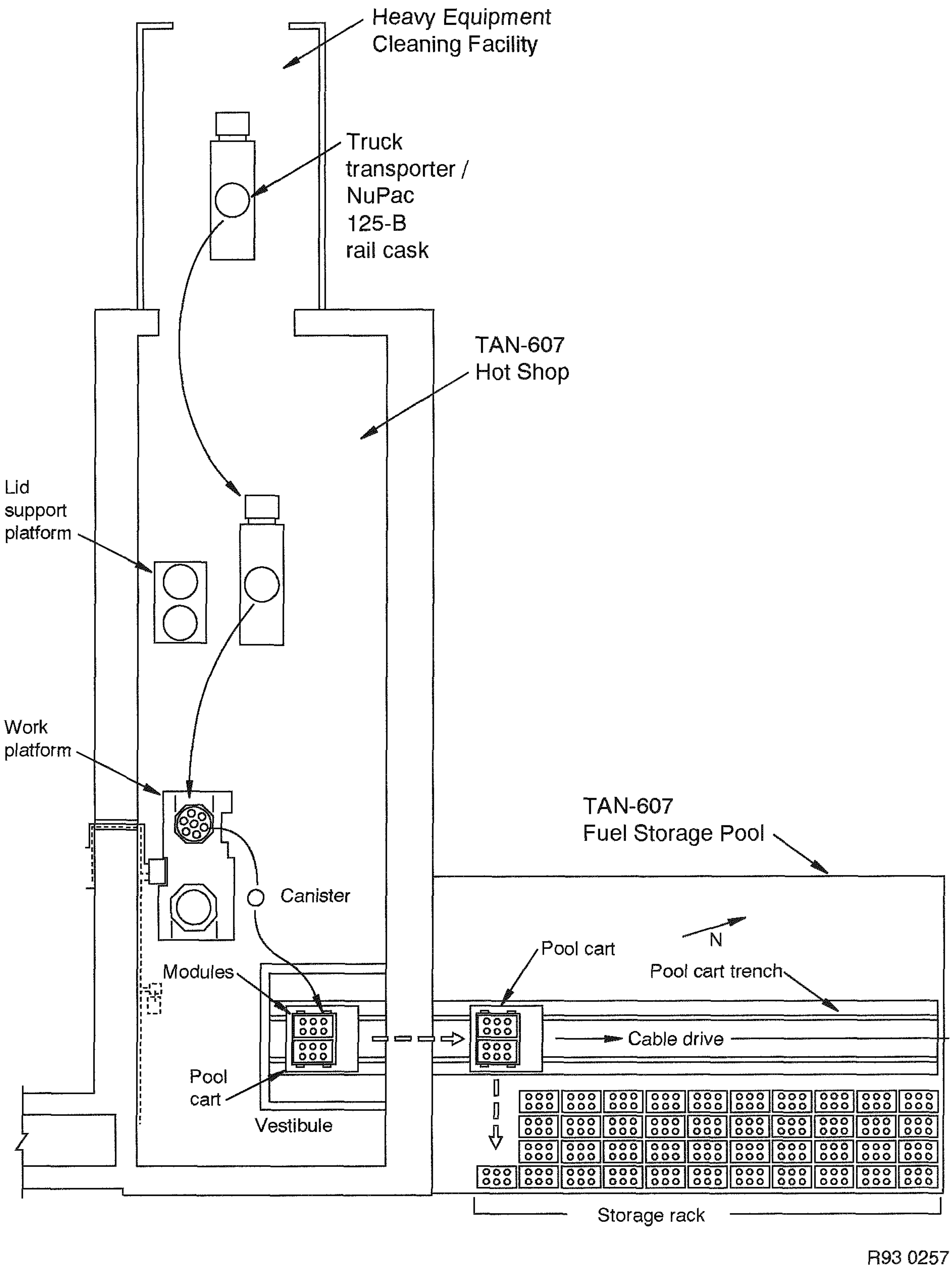

Figure 2-31. Diagram showing receipt of the loaded transporter at the TAN-607 Hot Shop through unloading and storage of the fuel debris canisters in the Fuel Storage Pool.

of the cask's outer and inner vessel lids. Following the "hands-on" activities, Hot Shop personnel left to perform the following operations remotely.

Using the special remote-handling equipment, canisters of TMI-2 core debris were transferred directly from a cask into a storage module on a transfer cart located at the bottom of the Hot Shop pool vestibule. Following operations on canisters described in Section 3.3.1.3.2, a full storage module was transported to the storage pool, using the transfer cart in a concrete channel built below the floor surface of the pool. A motor-driven bridge over the pool, with a 15-ton crane mounted on rails, was used to transfer the canister storage module from the cart to the storage location on the floor of the pool.

2.7.2 Documentation. Numerous plans and studies were required to determine the scope of the preparations needed at the INEL for receipt and storage of the TMI-2 core. The guidance document for all TMI-2 activities was the Program Management Plan for EG&G Idaho, Inc., TMI-2 Programs Division. One of the programs described in that plan was the TMI-2 Fuel and Waste Handling and Disposition Program, of which core receipt and storage was a project. The specific objectives of the Core Receipt and Storage Project were to:

- Provide engineering and technical support, and project controls to upgrade existing equipment at the INEL, specifically the TAN-607 Hot Shop
- Furnish additional equipment for the receipt and storage of the TMI-2 core, as necessary
- Provide safety documentation and operating procedures
- Provide for core receipt and storage operations.

A project plan, entitled *Core Activities Program: TMI-2 Core Receipt and Storage Project Plan,* was developed and included tasks in preparation for receipt and storage of the TMI-2 core debris at the INEL, as well as actual operations.[39] The plan considered project management; safety, environment, and quality; safeguards and security; procedures; deliverables; and costs and schedules for the receipt and storage activities at the INEL. The project plan identified that the following core receipt activities would be undertaken:

- Safety studies, which concentrated on such areas as preparation of facility SARs, reviews of criticality analyses, safety reviews of canister designs, and evaluation of storage rack module handling procedures
- Operational studies, which considered procedures for operations other than in the TAN Hot Shop, including a review of NuPac's proposed cask handling sequences, and identification of recovery sequences from potential unloading incidents
- Capital equipment support studies, which provided the operations-funded parts of the capital equipment upgrade projects, including development of functional/operational requirements, conceptual designs, and post-installation system testing.

The following documentation was prepared as a result of the project plan:

- A report evaluating the "life expectancy" of the TAN-607 storage pool, which showed that the pool would be useable for the next 30 years.
- A safety assessment for receipt and storage operations that contained specific information pertinent to the TMI-2 core debris, including description of cask and canisters; conduct of operations; and safety analyses of canister drop accidents, pyrophoricity, combustible gas generation, direct radiation exposures, release of radionuclides, and criticality safety.
- Revision to the existing Hot Shop Operational Safety Requirements Document (OSRD).
- Criticality analyses for the TMI-2 core debris canisters and storage racks.

- Analysis of the maximum weight of a loaded cask that could be placed on the floor of the TAN-607 Hot Shop in the cask unloading stand.
- Analysis showing the consequences of dropping a TMI-2 canister to the floor of the water pit vestibule.
- Detailed analysis of the water pit floor showing that the floor was adequate without a load spreading platform.
- Preventive maintenance procedures for the canister grapple and cask support skid trunnion bearings.
- A canister decontamination system study to provide a contingency plan in case canisters received were contaminated significantly in excess of INEL acceptance criteria.
- The *Transport Plan for Movement of TMI Core Debris Across INEL*, which contained the details of the movement of the cask system at the INEL.[40] The plan set forth the requirements and restrictions for movement of the cask across the Site, including the exact routes to be followed, and the special precautions such as the speed and escort requirements. Detailed operating procedures (DOPs) were developed based on the requirements in the plan.

The *Program Plan for Shipment, Storage, and Examination of TMI-2 Fuel* was the document that coordinated both the canister preparation and core transport activities at the TMI-TIO Office with the receipt and storage activities at the INEL.[6] The plan ensured that all TMI-2 and INEL requirements were met, technical information was effectively exchanged, and equipment, facility modifications, and operations were compatible and completed in the timeframe required to meet the core shipping schedule.

While the equipment preparations at both the TAN Hot Shop and CFA were underway, there was a parallel effort to prepare checklists and DOPs for use of the equipment in compliance with INEL safety documents and practices. A total of sixteen DOPs were prepared and approved for receipt and handling of the NuPac 125-B casks and core debris canisters at CFA and TAN (see Table 2-2).

Additionally, to ensure a smooth transfer of responsibility and documentation for each phase of a shipment (i.e., TMI-2 to the INEL, between facilities at the INEL, and return of each empty cask to TMI-2), seven sets of documents, in the form of checklists and two appendices, were developed.[41] Table 2-3 lists these documents and the appendices. Each TMI-2 shipment was accompanied by the checklists completed at TMI-2 and the INEL. (See Section 3.2.1 for the development and use of the checklists.)

2.7.3 Preparations. INEL preparations included efforts at both CFA and TAN, as well as along the truck transporter route between the two areas.

2.7.3.1 CFA Preparations. Preparations to receive and handle the NuPac 125-B casks at CFA required careful planning, evaluation of the capabilities of existing equipment, and procurement of additional equipment. The 200-ton gantry crane, which was originally used to handle large naval guns during the second world war, was to lift and move the casks from the train to a truck transporter. The crane was completely inspected and reconditioned. The original manufacturer was brought to the INEL to perform the inspection services. The structure and lift components of the crane were in good condition and the crane was recertified to its rated capacity. The crane underwent a thorough preventive maintenance inspection and was cleaned and painted before being placed into service. The concrete foundation for the crane rail system had started to deteriorate and was replaced.

Operations at CFA in off-loading a TMI-2 cask used a number of specially designed lifting components. In general, all lifting components were constructed from American Society for Testing and Materials (ASTM) A36 structural steel and high-strength alloy, where required. The lifting

Table 2-2. List of detailed operating procedures used at the INEL.

DOP number	DOP title
CFA Operations	
TMI-CFA-1	TMI-2 NuPac 125-B Cask—Removal of Environmental Cover and Overpacks
TMI-CFA-2	TMI-2 NuPac 125-B Cask—Transfer from Railcar to Truck Transporter by Gantry Crane
TMI-CFA-5	TMI-2 NuPac 125-B Cask—Transfer from Truck Transporter to Railcar by Gantry Crane
TMI-CFA-6	TMI-2 NuPac 125-B Cask—Replacement of Overpacks and Cask Environmental Cover
TMI-CFA-7[a]	TMI-2 NuPac 125-B Cask—Removal of Environmental Cover and Overpacks Using Gantry Crane
TMI-CFA-8[a]	TMI-2 NuPac 125-B Cask—Replacement of Overpacks and Cask Environmental Cover Using Gantry Crane
Transport Operations	
TMI-CFA-3	TMI-2 NuPac 125-B Cask—Movement by Truck Transporter from CFA to TAN
TMI-CFA-4	TMI-2 NuPac 125-B Cask—Movement by Truck Transporter from TAN to CFA
TAN Hot Shop Operations	
1.12.1	TMI-2 NuPac 125-B Cask Receipt and Handling at TAN
1.12.2	TMI-2 Canister Handling Procedures
1.12.3	TMI-2 NuPac 125-B Cask Shipment
1.12.4	TMI-2 Canister Watering Procedure
1.12.5	TMI-2 Canister Storage Procedure
1.12.6	TMI-2 Core Storage Canister Venting Procedure
1.12.7	TMI-2 Canister Gas Sampling
T07-101-TR01-B-S[b]	NuPac 125-B Rail Cask Trunnions (MICARTA insert inspection)

a. These procedures replaced DOP numbers TMI-CFA-1 and TMI-CFA-6 once it was determined that the overpacks could be removed by the gantry crane.

b. Preventive Maintenance Procedure (PM No.).

Table 2-3. List of documentation prepared for shipping TMI-2 core debris to the INEL and return of an empty cask.

Number	Type of information
1	Documents to be provided to EG&G Idaho TIO prior to shipment
2	Documents to be provided to the INEL at time of shipment
3	Documents to be retrieved from the cask shipment at the INEL
4	Documents required to transport the cask from CFA to TAN
5	Documents required to ship empty cask from TAN-607 Hot Shop to CFA
Appendix A	(Hot Shop Operations certification that the cask has been assembled and attached to the skid properly)
6	Documents required after transfer of the empty cask to the railcar
7	Documents required to place empty cask in storage
Appendix B	(Certification that the cask has been assembled, attached to the skid, and attached to the railcar properly)

devices were designed in accordance with the guidelines of the *DOE Hoisting and Rigging Manual* and ANSI N14.6. The following is a list of the major equipment involved at CFA in the cask handling activities: gantry crane; transport skid; truck transporter; tiedowns; tractor; trailer/jeep; horizontal lift fixture; overpack lift fixture; work platforms; environmental cover spreader bar; railcar positioning device; INEL locomotive; and miscellaneous equipment (e.g., overpack bolt storage boxes, overpack tiedown straps and attachments to railcars, overpack stands, cargo container, chain hoist for overpacks, and load test fixture for the horizontal lift fixture).

Some of this equipment had to be specially obtained and, if required, qualified. These items included the cask horizontal lift fixture and load test adapter; an environmental cover spreader bar to aid in removing and reassembling the cover; an overpack lift fixture; overpack storage stands; a work platform; and miscellaneous tools, straps, jacks, and boxes for storing items. A cargo container was set up beside the cask transfer area to house the smaller tools and equipment while not in use.

2.7.3.2 Preparation for Transport Between CFA and TAN. A heavy-duty, lowboy transport trailer from the INEL equipment pool, identified as the TWAMCO trailer, was evaluated, inspected, and modified for use in transporting the casks between CFA and TAN. The goose neck was extended to accommodate a KALYN jeep dolly so that the forward trailer load would be distributed between the jeep axles and the axles of an over-the-road tractor. To transfer the cask load to the main support rails of the trailer frame, crossbeams were designed and fabricated to interface the cask transport skid to the trailer. The assembled system was then load tested to verify its rated capacity of 100 tons (the loaded cask with transport skid and without overpacks weighed a maximum of 90 tons).

Before trial and dry runs, the route between CFA and TAN was checked to verify that the loaded transporter would not exceed the road capacity; the bridges were inspected and analyzed; and the *Transport Plan for Movement of TMI Core Debris Across the INEL*[40] was completed. During the dry run, the route between CFA and TAN was tested, including instrumenting the bridges. That test showed that the

TWAMCO trailer could be used to safely transport a loaded rail cask between CFA and TAN, confirming the analysis of the transport equipment.

2.7.3.3 TAN Preparation. Preparation of the TAN-607 Hot Shop for receipt and storage of the TMI-2 core debris required modification and upgrades of existing equipment, design and fabrication of new equipment, and preparation of safety and operational documentation for handling a cask and the core debris canisters.

Refurbishments, modifications, and upgrades in the Hot Shop facility included work on the overhead Hot Shop cranes, the radiation monitoring equipment, and the utility pedestals. The 100- and 10-ton cranes were inspected, tested, and repaired as required. The 100-ton crane break release and emergency load release was repaired. The lifting hook for the overhead manipulator (O-man) was repaired. One wall-mount manipulator was moved from the west side of the silo to the east side, where it could be used for canister storage activities in the storage pool vestibule area. Additional control stations in the south gallery were installed for operating the north manipulator. All of the equipment passed system operational testing before being approved for use.

Cask unloading preparations also included minor modifications to the cask loading and unloading stand, which was shared with the Spent Fuel Cask Testing Program as a cost savings initiative. The cask vertical lift fixture had to be designed to accommodate the limited space available in the existing cask stand. The canister handling, venting, and storage equipment was designed and fabricated. Two canister handling grapples were designed specifically for remote connection and transfer of the core debris canisters from the 125-B transport cask to the storage module. A dummy canister was fabricated from a head assembly, bulkhead, and bottom of a fuel canister, provided by GPU Nuclear. The dummy canister was filled with water and used for training, certifying the canister handling grapples, and testing the dewatering system.

The design of the core debris canister storage modules used at the INEL were selected based on a Kepner-Trego analysis. Seven alternatives were evaluated, and a module that would contain six canisters was selected as the best option (see Figure 2-32). The modules could be placed two at a time on the pool cart. An RFP resulted in a subcontract for design and fabrication of the canister storage racks and associated hoisting equipment being awarded to the U.S. Tool and Die Corp., Inc., of Allison Park, Pennsylvania. DOE Order ID 5480.1, Chapter V, "Criticality Safety," allowed the use of fixed poisons for criticality control provided that the material was protected and that its presence was periodically verified.[f] The module design included inspectable neutron absorber elements for potential use in criticality control during a hypothetical pool draining accident, which would be the worst-case event from a criticality standpoint for storage of the TMI-2 core debris. The equipment and procedures for periodic inspection of the neutron absorbers were completed.

Although the canisters were shipped dewatered to satisfy transportation safety requirements, each was refilled and stored water-filled, but continuously vented, to ensure safe long-term storage at the INEL. A canister watering/dewatering cart, located near the storage pool vestibule in the Hot Shop, was designed and fabricated to add demineralized water into a canister while in the vestibule before being transferred to the pool. The gas being displaced during canister refilling operations was routed from the cart into the high-efficiency particulate air (HEPA) filter system, which is part of the Hot Shop heating and ventilation (H&V) system. The cart was also designed to remove water from the canisters if required.

While in storage, the canisters are permanently vented through vent tubes to the storage building

f. The canisters were also subcritical by use of fixed poisons for criticality control, but those poisons were internal to the canister and the designs were not readily inspectable in accordance with DOE Order 5480.1.

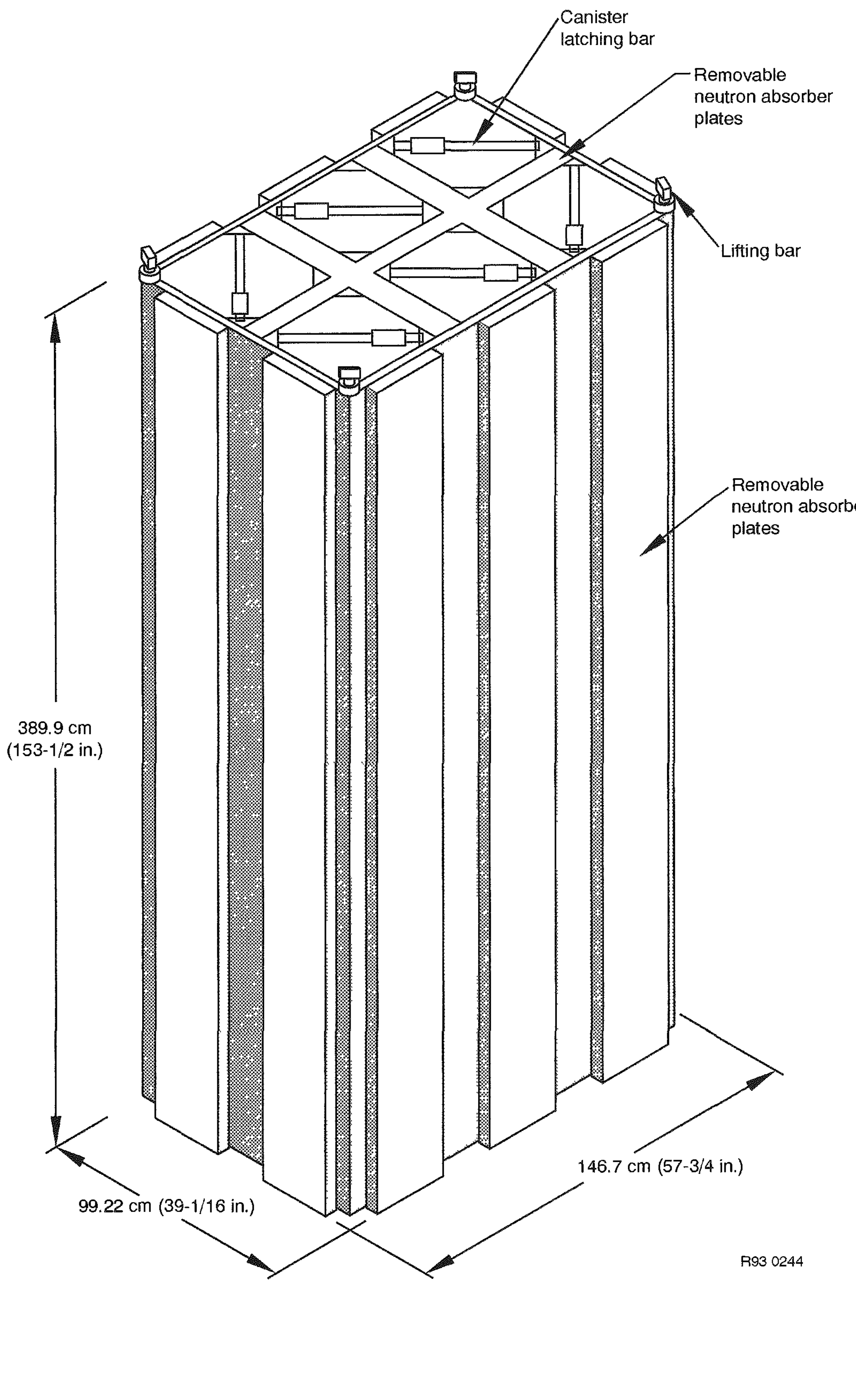

Figure 2-32. Diagram of TMI-2 core debris canister storage module.

environment to remove the small amounts of hydrogen gas that might evolve from radiolytic gas generation. A test of the H&V system of the storage pool building was performed to show that there was sufficient H&V air flow capacity to handle worst-case projections of gas generation from the canisters. The test also showed that there was no stratification of the air in the building.

The 15-ton bridge crane over the storage pool was inspected, preventive maintenance was performed, and the lifting hook was changed out and load tested. A work platform was added to the bridge so that technicians could perform operations on the canisters and storage modules while the canisters were in storage.

A new ion exchange water cleanup system requiring less and lighter shielding was designed and installed for the storage pool. The new system provided more efficient water chemistry control than the system it replaced.

The underwater pool transfer cart was removed, examined, refurbished, and modified to support two canister storage modules at one time. The pool cart drive assembly, cable drive, and variable speed electrical installation was refurbished, and as-built drawings were made of the pool cart and cart drive. The cart cable system was examined, an electrical variable speed unit was added, and end supports at the north and south end of the pool were redesigned and added. System operational testing was successfully performed in May 1986.

Two pieces of equipment designed as precautionary measures were never used. The first was equipment to dispose of the vent lines from canisters if the lines needed to be replaced and were too contaminated for normal disposal. The second was an emergency canister support stand that could have been used to support a loaded canister that was being transferred from a cask to the pool should there be a failure of the crane. The stand would support the canister while the grapple was uncoupled and the crane was moved to a protected area for repair.

2.7.4 Dry Runs. Two dry runs were conducted at the INEL. In October 1985, the first dry run without a cask was completed using a dummy canister to check canister receipt and storage equipment and operations in the TAN-607 Hot Shop. By January 1986, preparations for handling the TMI-2 shipments were nearly complete. The cask horizontal lift fixture was received and attached to the gantry crane where it was load tested using the load test fixture. Modifications to the TWAMCO trailer were completed, and the KALYN jeep was received. A dry run with the transporter loaded with weights to simulate a loaded cask was completed over the route between CFA and TAN for training personnel and to evaluate procedures.

In January 1986, one of the NuPac 125-B casks was delivered to the INEL, and a dry run of the entire sequence of receipt and storage operations at the INEL was performed. Handling equipment was tested and modified as needed. The environmental cover and two overpacks were removed from the cask, and the cask and skid were transferred from the railcar to the transporter. Once the dry run operations at CFA were completed, the loaded transporter was shipped to TAN and backed into the Hot Shop for personnel training and to test the Hot Shop equipment. The cask was transferred from the transporter to the work platform; both lids and the shield plugs were removed; and the dummy canister was moved in and out of each of the seven canister cavities in the ICV of the cask. The cask was reassembled and returned to the transporter. The cask was then returned to CFA and transferred from the transporter to the railcar. The overpacks were reassembled, the environmental cover was installed, and the loaded railcar was readied for transport.

This dry run thoroughly tested all of the cask and canister handling equipment and the DOPs. Several needed improvements were identified. The first was that the dynamometer between the overhead crane hook and the canister grapple could not always be read during removal of the canister. The dynamometer was needed to monitor the load on the grapple during the lift of a canister from a cask to ensure that the canister did not bind up in the cask and overload the grapple. The dynamometer was replaced with a load cell that had an electronic readout in the operating gallery area that could be easily read by the technicians.

Secondly, the ability of the technicians to see the canisters being lowered into the storage module in the vestibule pool needed to be improved. Visibility was improved by adding a pan, zoom, and tilt capability to the underwater camera system and by installing better underwater lighting.

Finally, the canister grapple designed at TMI-2 for TMI-2 equipment was not fully compatible with the remote handling operations needed in the Hot Shop. The side loads on the grapple from electrical control cords caused the grapple, as originally designed, to hang at an angle that made it difficult to engage canisters remotely. The grapple was modified to specifically meet the needs of the Hot Shop.

Once all of the equipment, operations, and supporting documentation had been assembled and checked out, a readiness review was conducted. Personnel represented on the readiness review committee included operations, safety, quality, engineering, and DOE-ID. The review covered personnel training, procedures, equipment, and facility preparation. Documents used to perform activities and implement requirements were compared to DOPs, management plans, SARs, OSRDs, standard practices, standing directives, environmental evaluations, design review meeting minutes and comment resolution letters, quality program plans, specifications, site work releases, the *DOE Hoisting and Rigging Manual;* EG&G Idaho's *Safety Manual, Quality Manual,* and *Operations and Maintenance Manual*; engineering design files; and letters. Once all of the open items identified by the readiness review were resolved, a facility operations approval was granted, and all capital equipment needed for receipt and storage was turned over to the Hot Shop.

2.8 Rail Carrier Negotiations

EG&G Idaho began negotiations with UP in the last half of 1984 to provide transport services for the TMI-2 core debris. UP was requested to provide a price for round trip service from Middletown, Pennsylvania, to Scoville, Idaho (i.e., from the TMI-2 site, near Harrisburg, Pennsylvania, to a rail siding near the INEL site boundary). EG&G Idaho's traffic manager was the exclusive contact with UP for the earliest railroad negotiations.

UP serves the INEL site and, from the earliest discussions, proposed the route eventually used for all shipments: pickup at the TMI-2 site by Conrail with transport over the mainline tracks west through Pennsylvania, Ohio, Indiana, and Illinois to East St. Louis, Illinois; and transfer through East St. Louis by the Alton and Southern Railroad to UP with transport by UP over mainline tracks further west through Missouri, Kansas, Nebraska, and Wyoming to the INEL site in Idaho.

As the rail carrier to EG&G Idaho, UP obtained prices from all other railroads for whatever freight EG&G Idaho needed to have transported. In this case, the price and conditions for service from Conrail on the eastern leg of the shipments were obtained by UP from Conrail and submitted as a single quote to EG&G Idaho.

As a matter of logistics, UP was the *only rail* carrier serving the INEL site and Conrail was the *only practical* carrier serving the TMI site [a relatively short haul by Conrail would connect to the Chessie System (CSX)]. As a matter of capability, UP was (and is) a principal carrier in the west and Conrail is likewise in the east. Both are major transport companies for rail shipment of hazardous commodities over high-quality mainline tracks.

Except for contacts with CSX regarding an alternate route to East St. Louis, discussions and meetings before the first shipment involved only UP or Conrail or both. There were initial meetings to introduce the railroad companies to the

TMI-2 core debris shipping program in general and DOE's expectations of the rail carriers in complying with the DOE's special requirements for transport of unclassified spent nuclear fuel by rail. The first of these meetings was on November 20, 1985, at TMI-2 with EG&G Idaho, GPU Nuclear, and Conrail. The second was on January 21, 1986, in Omaha, Nebraska, with EG&G Idaho and UP.

A meeting to review plans with management representatives was held on March 25, 1986, in Harrisburg, Pennsylvania, with EG&G Idaho, UP, Conrail, DOE-ID-TMI, DOE-ID, and DOE Defense Program (DOE-DP). Two additional meetings on planning were held at TMI-2 as the date for the first shipment approached. A meeting was held on July 9, 1986, with EG&G Idaho, UP, Conrail, and DOE-ID-TMI to review preshipment inspection, public affairs, and security interfaces. A meeting was also held on July 15, 1986, with technical representatives from EG&G Idaho, GPU Nuclear, UP, Conrail, and DOE-ID-TMI. This meeting firmly established the final arrangements before the initial shipment of TMI-2 core debris that left on July 20, 1986.

From the initial discussions with UP, to the meetings before the shipment and even further on into the shipping campaign, there were some major areas of disagreement between DOE and the railroads, principally Conrail. These disagreements required extensive negotiations.

2.8.1 Contractual Agreements. EG&G Idaho originally entered into discussions with UP to coordinate the development of a single proposal for transport of the 125-B casks from TMI-2 to Scoville and back. In other words, UP was to price alternative carriers east of the UP service area and coordinate any resulting agreement(s) with the selected railroad(s). This approach was of value for initially obtaining proposed alternatives for carriers and routes, but not successful in obtaining a single agreement for both UP and Conrail.

When UP provided the first price proposal on January 4, 1985, information on alternate routes and carriers was submitted to EG&G Idaho. Routes through Chicago and St. Louis were identified using Conrail, Missouri Pacific, Illinois Central Gulf, and Norfolk & Western. Alternate transit times were also provided showing the effects of 35 and 50 mph speeds. Conditions on speed restrictions imposed by each rail carrier for radioactive materials were identified, as was each carrier's policy on the use of regular or special trains.

In UP's first price proposal, the cost for a loaded cask was $15.59 per 100-lb weight (cwt) with a minimum weight of 240,000 lb per loaded railcar. The cost for an empty cask was $14.61 per cwt and minimum weight of 225,000 lb. Negotiations by the Transportation Management Department at DOE-DP on behalf of EG&G Idaho reduced the rates to $15.28 per cwt loaded and $6.89 per cwt empty, both with a 225,000 lb minimum. In July 1985, UP issued a Section 10721 quote pursuant to United States Code (USC) 49 USC 10721 (for government freight) for these negotiated rates. The quote applied to both the UP and Conrail legs of the shipments (i.e., a single quote for the costs of both rail carriers).

Just before the start of the shipments in July 1986, as a result of negotiations on accessorial charges and expedited service, UP and Conrail determined that each would require a separate contract with EG&G Idaho. The contract with UP was signed the week before the first shipment, but the contract with Conrail was not achieved until February 1987 (Conrail moved the first few shipments using a Government Rate Tender Quote). Special terms and conditions for UP and Conrail were as discussed below. Considerable effort went into these agreements and there were many differences in acceptable terms and conditions that were negotiated for some time after the start of the shipments.

2.8.2 Special Train Service. The single most contentious point in the rail carrier negotiations was over the type of service [i.e., regular or special trains (also known as dedicated trains or exclusive-use trains)]. Special train service is a type of service typically proposed by some railroads for hazardous material shipments, especially spent nuclear fuel, and means that the only commodity transported on the train is the hazardous material, in this case the TMI-2 core debris in a 125-B cask(s). Restrictions on the maximum speed of a special train may or may not apply, depending upon the rail carrier.

For spent fuel shipments, DOE has insisted that rail carriers provide regular train service at tariff rates set by the U.S. Interstate Commerce Commission. Rail carriers had refused this common carrier obligation but had lost in appeals to the courts during years of litigation. DOE's opinion is that these shipments can be safely transported as regular freight because of the packaging required for the radioactive material being transported. A spent fuel package must survive severe accident conditions and is the principal means of ensuring the health and safety of the public for such shipments. Administrative controls, such as continuous surveillance of a cask during transit by the crew, are secondary in importance.

In terms of the sequence of negotiations with the rail carriers, EG&G Idaho first obtained rates for regular train freight service in 1985. Then, in early 1986, EG&G Idaho requested prices for accessorial charges to provide constant surveillance of the casks during transport, and the detailed schedule and route for the normal or regular train service.

UP responded in February 1986 with a price of $4,000 per car for constant surveillance in regular train service, a mainline route from East St. Louis, Illinois, to Scoville, Idaho, and a scheduled transit time of six days for a loaded cask. Conrail responded in April 1986 with a price of $17,500 for each loaded cask for constant surveillance in regular train service *in local trains*, a mainline route from Middletown, Pennsylvania, to East St. Louis, Illinois, and a scheduled transit time of 7.7 days (186 hours) due to the use of local trains. Conrail refused, and was not required by regulation, to offer regular train service on a first-available through-train to East St. Louis. Conrail also offered to provide expedited service by a special train for $21,500 using mainline tracks, resulting in a transit time of 32 hours.

In effect, Conrail was offering to save six days per trip using special train service at a price comparable to the cost of the constant surveillance DOE was requiring. However, when Conrail's insistence on special trains became apparent with this offer, EG&G Idaho, on behalf of DOE, contacted CSX independent of UP and Conrail to determine if there was a willingness to use regular train service for the TMI-2 shipments. The response from CSX did not offer a meaningful alternative to Conrail to get the TMI-2 shipments to East St. Louis. Regular train service on the proposed route on CSX would have required five days and the track was not of as high a quality as available with Conrail's service.

By July 1986, DOE agreed that the first three TMI-2 shipments would use Conrail's expedited service on a special train. This programmatic position was based on a need to move the first few loads of core debris to the INEL for examination of debris and core bore samples as part of the accident evaluation research program. Also, these shipments would allow the shipping program to gain experience under the relatively tight control of special trains as compared to what the railroads were offering for regular train service. (See Section 3.2.2 for follow-on developments related to special trains.)

During the week before the first shipment, EG&G Idaho agreed to a price of $17,500 for Conrail's expedited service on special trains. This reflected negotiation with Conrail down to the proposed price for constant surveillance of a regular train in local service. This agreement with Conrail prompted UP to revise their price proposal to $29,500 for special train service also. These were the prices agreed to with the railroads before the first shipment from TMI-2 to the INEL.

2.8.3 In-Transit Requirements. The price agreed to with both railroads provided the constant surveillance required by EG&G Idaho. This was a DOE requirement for each carrier to maintain a constant or continuous surveillance of each loaded cask and railcar during the entire trip (i.e., in transit, in yards for crew changes, and in terminals for transfers to another carrier). This requirement differed from the escort requirements imposed by NRC at that time.

Conrail took exception to DOE's requirements and replaced them with their interpretation of NRC's then current requirements; each shipment was to be accompanied by a road foreman and a Conrail security officer; the train was to receive continuous surveillance throughout movement by the train crew and supervisory officers and while in yards and terminals. The train was also to be inspected, on both sides, immediately upon stopping. The cost for this was included in Conrail's charge for expedited service.

UP also planned for extra personnel aboard a train to perform the constant surveillance, but in a manner more consistent with the intent of DOE's requirement. DOE requested that a member of the train crew, although not the engineer and not necessarily a security officer, be positioned to frequently observe a loaded cask railcar (need not maintain continuous observation) and to maintain a constant surveillance when the train stopped.

Except for certain special issues such as inspections by State agencies at points along the route, time-of-day to start the loaded shipments, and other issues discussed later in this report, EG&G Idaho did not question the rail companies' requirements to be imposed on the conduct of operations except to understand the railroads' actions. This comment relates to such things as crew changeout policies, speed control, and policies for controlling movement near other trains.

Conrail imposed a special train speed limit of 30 mph, due to a company-held position that low speeds are in the interest of safety. Also, operating procedures required Conrail's special train to stop when being met or passed enroute by another train. This particular requirement placed an interesting work load upon the escorts who were required to get out and inspect the railcar at every stop. Conrail's other trains meeting or passing a TMI-2 special train were to be restricted to 40 mph. In contrast to Conrail, the UP service area consisted of much more open country and generally allowed UP's special trains to travel at the same speeds as their regular trains. This included reducing the speed of the special train in areas of congestion where the speed of all trains was normally restricted.

Two other related requirements were to accept DOE representatives on trains and to provide a caboose for them. DOE personnel were initially intended to accompany a few of the first shipments to address any out-of-the-ordinary situations and perform "time and motion" studies. Restrictions on non-railroad company personnel in the train engines meant a caboose was required on a train for the DOE representatives. For many modern railroad companies, a caboose is not required on a train and negotiations with railroad unions regarding the need for a caboose is a significant issue. Adding a caboose and idler cars before and after the railcar with the cask was agreed to by both rail carriers as part of the price for expedited service.

DOE also had requirements for emergency response actions, control of shipping papers, communications during transit, and other logistical considerations. Considerably more discussion on rail operations and events in-transit are provided below and in the sections on public relations and transport operations.

2.9 Route Selection and Studies

Selecting a railroad route for transport of TMI-2 core debris was an important consideration in the program, but was not so much a process of needing to decide among available routes as it was a process to confirm that the route proposed by the rail carriers was the safest alternative available. DOE's involvement was principally in negotiating to select the rail carriers and evaluating the safety of the routes available from each carrier. DOE's major decision was selection of Conrail as the carrier rather than CSX. There were evaluations of other routes on Conrail's lines, but since the proposed route was found to be the safest available, there was not much need for negotiation with Conrail on other possible routes on Conrail's lines. For UP, there was not even a reason to consider an alternate carrier, and the proposed route was, like Conrail's, the safest available.

Thus, the route selection decision was principally the choice of rail carrier for the majority of the eastern part of the trip. The decision on the rail carrier was not made until EG&G Idaho and DOE were certain there was not a viable alternative to Conrail's service, which essentially required use of special trains. A potential route using through trains on CSX was available but when compared to using Conrail's route over mainline tracks, the safety in choosing Conrail as the carrier was clear.

The added costs for special train service by Conrail was an issue in the route (carrier) selection process since DOT did not at that time and still does not regulate railroad route selection for this type of radioactive material. This contrasts to route selection for highway transport of the same material, which was then and is still now regulated by DOT. In the absence of DOT-prescribed methods for railroad route selection, EG&G Idaho, in close coordination with DOE, selected Conrail as the eastern carrier, which in turn selected the route over Conrail's mainline tracks to East St. Louis. The route (carrier) selection process was based on achieving multiple safety-related objectives.

The principal DOE objectives in selecting a route (and carriers) from the alternatives were to select a route that had the shortest total distance, used the greatest percentage of high quality tracks, and minimized the number of times the railcars with the TMI-2 cask would be switched from one train to another and transferred from one rail carrier to another. Taken together, these objectives seemingly amounted to achieving the most expeditious route with the shortest amount of travel time. Selecting an "expeditious route" actually involved evaluating each of these multiple objectives separately and adding the cumulative effect. However, there was not a prescribed method to rank the relative importance of each. From a decisionmaking perspective, DOE was fortunate that there was a single route that was close to achieving each of the objectives simultaneously.

DOE was not so fortunate with the selected route from the public relations perspective, since the route passed through several major metropolitan areas. As is evident from DOT's highway route selection criteria, travel around, rather than through, a city with a beltway is a preferred highway route.[42] However, for railroad routes, the highest quality tracks is typically through cities, not around them, and the railroad routes around cities are circuitous since railroads do not typically have beltways around cities. In general, getting off of the mainline tracks to avoid travel through a city means more miles of lessor quality tracks than using a route through a city.

Since railroad route selection was not prescribed by Federal regulation, EG&G Idaho did not have a regulatory constraint to consider. However, as noted previously, selection of the route for the TMI-2 core debris shipments was constrained to originate at the TMI site near Middletown, Pennsylvania, with rail service provided only by Conrail, and to terminate at the Scoville Siding at the INEL, Idaho, with rail service provided only by UP. The route for the TMI-2 shipments was thus based on these two physical constraints plus meeting DOE's objectives to optimize public safety (i.e., expeditious transport using shortest distance, highest quality tracks, and fewest number of switches and transfers). An additional factor was the cost for the shipments (special trains), but cost was not a determining factor.

The route and carrier selection process began in late 1984 by DOE asking UP for a round trip price from TMI-2 to the INEL. UP was to recommend the most appropriate routes using knowledge of their rail system and its connections to other eastern U.S. carriers. This approach used UP's expertise in rail transport activities on a day-to-day basis. UP obtained alternative routes involving several rail carriers and proposed routes. From these alternatives, UP proposed service with just the two carriers that would be involved in any shipment due to the physical constraints: UP and Conrail. In a July 1985 quote, UP specified Conrail to East St. Louis and UP to the INEL. Although the details of the exact route and schedule were not provided in the quote, the route through East St. Louis represented the combined recommendation from UP and Conrail as the safest route based on extensive experience with their own train operations, mainline tracks, and handling of hazardous materials.

Separate from this recommendation from the rail carriers, EG&G Idaho and DOE evaluated the safety of the proposed route to confirm it as the best choice in meeting DOE's objectives. In January 1986, EG&G Idaho hired ALK Associates Inc. (ALK), an independent consulting company specializing in rail routing studies for shippers of hazardous commodities. In February 1986, DOE-TMI also had the Oak Ridge National Laboratory (ORNL) evaluate the rail route using a computerized model created for studying rail routing decisions for future rail shipments of spent nuclear fuel from reactors to a Federal repository.

The objective of the ALK evaluations was to ensure that the proposed route maximized public safety in a general or national sense with a route that best served public safety as a whole (i.e., without special consideration to State or local interests in routing around specific places). Local sentiment for routing of radioactive materials can be commonly characterized by the phrase, "Not through my backyard." However, such preferences by specific cities, counties, or States was at odds with the overall objective to expedite a shipment.

The initial ALK study was performed by providing only the origin and destination as baseline parameters for analysis. The study used a computerized data base taken from the Interstate Commerce Commission (rail traffic volumes) and the Federal Railroad Administration (accident files). The study evaluated the EG&G Idaho specified route (TMI-2 to East St. Louis to the INEL) and four other routes that are called benchmarks. The benchmarks identified (a) the route that would likely have the shortest travel time and highest travel time reliability, (b) the route that best avoids populated areas, (c) the route that best avoids the sites of general commodity accidents, and (d) the route that best avoids the sites of hazardous commodity accidents.

For each of these alternative routes, the ALK results presented the following information: total miles, number of rail carriers, population within one mile of a corridor, miles of tracks of each quality classification, relative transit time, accident probability (all commodities), and accident probability (hazardous materials).

From the results, the EG&G Idaho specified route (the UP and Conrail proposed route) was identified as being the same route as the benchmark route with the shortest travel time and highest travel time reliability. The benchmark route that best avoided populated areas was found to have more total miles and considerably more miles on lower quality tracks. The route that best avoided the sites of general commodity accidents was nearly identical to the proposed route, while the route that best avoided the sites of hazardous commodity accidents went north and then west, passing through New York State.

While these results confirmed that the proposed route best met DOE's safety objectives, DOE's interest in ensuring that all available alternatives were considered led to a parallel study by ORNL. Using a model similar to ALK, the ORNL study evaluated the proposed route and four alternate routes. Two alternates were through Chicago rather than East St. Louis and, although slightly shorter [3,900 versus 3,700 km (2,400 versus 2,300 mi)], the routes involved an additional transfer to another rail carrier and would have passed through more densely populated areas (1,600,000 versus 1,200,000 persons within 1 km along the route). The third alternate route was the minimum distance route, but saved only 10 km (6 mi) off of the shortest alternate route through Chicago and would have involved even more rail carrier transfers (a total of six carriers). The fourth alternate route was to minimize the distance on Conrail and transfer the shipment to another carrier as soon as possible. The closest rail carrier to the TMI-2 site was CSX (B&O

Railroad), and when this result became known, EG&G Idaho began negotiations with CSX.

The purpose in negotiating with CSX was to evaluate whether DOE could find a rail carrier willing to place the TMI-2 shipments on through train service (rather than require special trains like Conrail), and willing to meet DOE's safety objectives, provide constant surveillance, and meet other DOE in-transit requirements at a reasonable cost. EG&G Idaho's traffic manager requested CSX to provide a price, route, and schedule for consideration. Independently, EG&G Idaho also had ALK perform an additional study of a route using CSX. The route proposed by CSX in April 1986 was longer in total miles than the Conrail route, had more miles of lower quality tracks, switched the railcars with the TMI-2 casks to different through trains, and required extra days to reach East St. Louis. Because of the constraints within the CSX network of tracks, the route CSX proposed would have made a figure "S" when placed over the Conrail route. The route proposed by CSX was determined to be less safe than the Conrail route and EG&G Idaho ended negotiations with CSX to finalize agreements with Conrail.

The outcome of these rail routing studies confirmed that the route proposed by UP and Conrail most closely met all of DOE's objectives for safe and expeditious transport of the TMI-2 core debris. Other routes were judged to be less desirable because of multiple rail carriers, added train transfers, longer transit times, and lesser quality tracks. Travel to East St. Louis via Conrail with a transfer by the Alton and Southern Railroad to UP had the least number of interchanges, was projected as the quickest and nearly the shortest route, and overall had 96% high-quality tracks.

Those studies also demonstrated that maintaining DOE's safety objectives could not be met, while, at the same time, avoiding all high population density centers. Again, the highest quality track typically goes through highly populated areas; avoiding such areas increases transit distance and time over poorer quality track. After all studies and analyses were correlated, the route finally selected had the lowest population density for cross-country transit when DOE's safety objectives for routing were considered.

To further ensure the safety of the shipments, the entire rail route was inspected by the Federal Railroad Administration (FRA) before the start of the first shipment. As a mainline east to west across the United States, the quality of the track on the route was excellent and was essentially under constant surveillance and maintenance by the rail carriers.

The route selected is shown in Figure 2-33. The major cities on the route were Harrisburg, Pennsylvania; Pittsburgh, Pennsylvania; Indianapolis, Indiana; Terre Haute, Indiana; St. Louis, Missouri; Kansas City, Missouri; Topeka, Kansas; and Cheyenne, Wyoming. The route included a short distance on a carrier, called Alton and Southern Railways (A&S), which transferred trains from Conrail to UP at East St. Louis. The total one-way distance was 3,835 km (2,383 mi). Of this, the Conrail portion was 1,431 km (889 mi); A&S, about 24 km (15 mi); and UP, the balance. A listing of the original stops on the route and scheduled transit times is shown in Table 2-4. However, the schedule in this table was the original estimate; the schedule actually achieved is discussed in Section 3.2.6. Also, because of public involvement, there were other aspects of the schedule, which are discussed in the institutional issues section.

2.10 Institutional Issues

Anticipating that transporting core debris from TMI to the INEL would be a sensitive public issue, DOE authorized a number of special efforts to address institutional issues (also identified as public relations and community relations in various reports) during preparation for and conduct of the shipping campaign. In this section, the effort undertaken in preparation for shipping is discussed. Section 3.5 will present activities during the campaign to address institutional issues, although there is considerable overlap because some issues that were considered and addressed

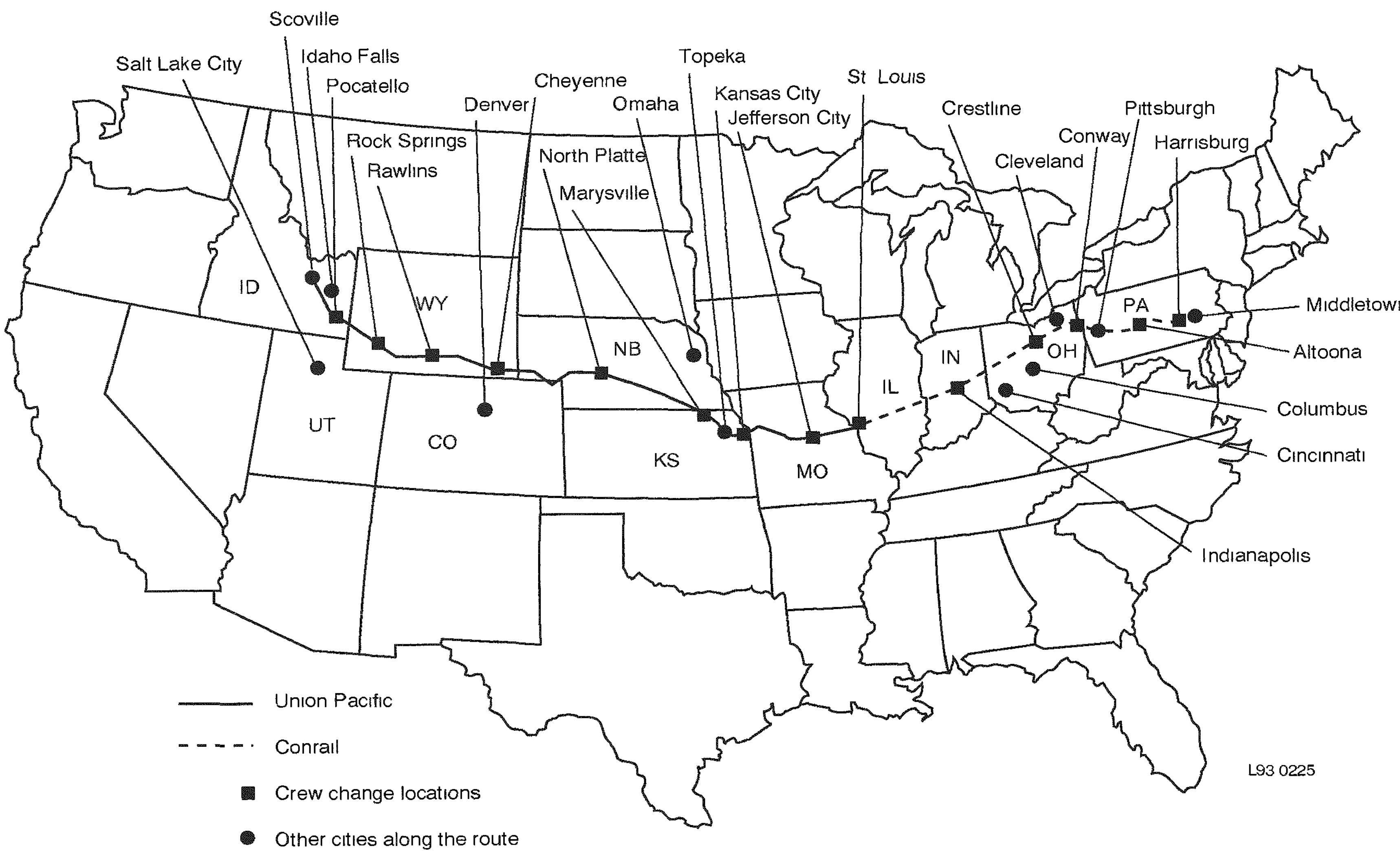

Figure 2-33. Rail route of the TMI-2 core debris shipments from TMI-2 to the INEL.

Table 2-4. Original route, schedule, and crew changeout points for the TMI-2 transport campaign.

	City stops and crew changes	Conrail/UP schedules times	Day number
LV	Middletown, Pennsylvania	11:30 a.m. EST	1
AR	Harrisburg, Pennsylvania	12:01 p.m. EST	1
LV	Harrisburg, Pennsylvania	12:15 p.m. EST	1
AR	Altoona, Pennsylvania	6:50 p.m. EST	1
LV	Altoona, Pennsylvania	7:05 p.m. EST	1
AR	Conway, Pennsylvania	2:45 a.m. EST	2
LV	Conway, Pennsylvania	4:00 a.m. EST	2
AR	Crestline, Ohio	11:20 a.m. EST	2
LV	Crestline, Ohio	11:35 a.m. EST	2
AR	Indianapolis, Indiana	9:30 p.m. EST	2
LV	Indianapolis, Indiana	9:45 p.m. EST	2
AR	East St. Louis, Missouri	9:00 a.m. CST	3
LV	East St. Louis, Missouri	9:30 a.m. CST	3
AR	Jefferson City, Missouri	2:30 p.m. CST	3
LV	Jefferson City, Missouri	3:35 p.m. CST	3
AR	Kansas City, Kansas	8:05 p.m. CST	3
LV	Kansas City, Kansas	8:20 p.m. CST	3
AR	Marysville, Kansas	12:50 a.m. CST	4
LV	Marysville, Kansas	12:55 a.m. CST	4
AR	North Platte, Nebraska	8:25 a.m. CST	4
LV	North Platte, Nebraska	8:30 a.m. CST	4
AR	Cheyenne, Wyoming	1:45 p.m. MST	4
LV	Cheyenne, Wyoming	1:50 p.m. MST	4
AR	Rawlins, Wyoming	7:05 p.m. MST	4
LV	Rawlins, Wyoming	7:10 p.m. MST	4
AR	Green River, Wyoming	11:10 p.m. MST	4
LV	Green River, Wyoming	11:15 p.m. MST	4
AR	Pocatello, Idaho	6:15 a.m. MST	5
LV	Pocatello, Idaho	6:20 a.m. MST	5
AR	Scoville, Idaho	10:25 a.m. MST	5

AR arrive

CST Central Standard Time

EST Eastern Standard Time

LV leave

MST Mountain Standard Time.

before the start of the shipments were indeed issues requiring additional attention after the shipments began.

An early agreement between GPU Nuclear, the rail companies, and DOE was that DOE (or its contractor) would assume primary responsibility for the interface with the public regarding the campaign. With a few exceptions, this agreement was largely maintained. Public relations required a large effort that resulted in a significant exchange of information between DOE and the public and resulted in some changes to operational procedures as the campaign progressed. The overall effort included State and local government preshipment notification procedures; working relationships with the States; interaction with the public and public meetings in various formats; media interaction; written responses to a widely diverse range of outside parties, including private citizens, elected officials, organized groups, and the media; governmental inquiries and investigations; preparation of input to organizations tracking the progress of activities; press conferences; and public displays of equipment.

In preparing for the TMI-2 core debris shipping campaign, EG&G Idaho reviewed DOE policy regarding notifications and communications with the States and/or local governments for radioactive materials shipments, made early decisions regarding how to interact with the public, and evaluated needs regarding emergency preparedness.

2.10.1 Working with the States/ Notification Procedures. In early 1986, DOE's policy for interacting with the States was generic notification through the use of booklets such as "Shipment of Radioactive Materials by the U.S. Department of Energy" and supplemental "courtesy communications," that is, telephone communication with governors' designees. Early documents aimed at enhancing procedures for the TMI-2 campaign were prepared by members of the TMI-2 shipping team and were variously entitled "Notification to the States Regarding Transportation of Unclassified, Spent Nuclear Fuel by the U.S. Department of Energy" and "Generic Implementation Plan with Reference to TMI" (for interacting with the States). Although these documents were not finalized, they sparked considerable debate within DOE offices, contributed to the promulgation of notably altered DOE notification policies for shipments of unclassified spent fuel and high-level radioactive waste, early in 1987, and resulted in early DOE guidelines for the TMI campaign, which follow:

- The TMI-2 core debris shipments were to be carried out in full conformance with DOE transportation policy and fully coordinated with several DOE offices [DOE-ID, DOE Office of Nuclear Energy (DOE-NE), DOE-DP, and DOE Office of Civilian Radioactive Waste Management (OCRWM)].

- Initial notification to the involved States would be made by the EG&G Idaho traffic manager to the governors' designees at least 45 days before the start of the shipping campaign.

- All notifications were to be made by telephone rather than written.

- Discussions with the States with respect to any further requests on their part should be verbal rather than written to the extent feasible. (However, many written communications would occur as a result of replies to letters from governors to DOE offices and special issues with State offices, for example.)

- Requests by a governor's designee for notification of individual shipments was to be honored if such notification was for the purpose of carrying out State activities such as inspection or preparation for emergency responses. Such notification was for these official purposes only and the States were to be advised that this information should only be released on a "need-to-know" basis. (For security reasons, a policy of nondisclosure of exact time-of-day scheduling to the general populous was in effect.)

- Consistent with DOE policy, requests by States that special trains be required were not to be honored.

- Requests for State inspections were to be honored to the extent that such inspections were customary for all similar shipments and that the progress of a shipment not be impeded.

- Requests that State vehicles escort a shipment were to be honored to the extent that such escorts did not delay the shipment.

- Upon receipt of a State request for matters such as the above, the organization receiving the request was to promptly notify the Office of LWR Safety and Technology of DOE-NE. Agreement was to be reached in individual cases as to the proper lead (e.g., EG&G, Idaho, DOE-ID, DOE-NE, or DOE-DP). The lead organization would then have the responsibility of ensuring that all other organizations were advised of the interactions taking place.

- The lead organization would then interact with the State and coordinate the response with DOE-NE.

- A note documenting the agreement reached was to be distributed by the lead organization to DOE-NE, DOE-ID, EG&G Idaho, DOE-DP, and OCRWM.

In implementing these guidelines, EG&G Idaho's traffic manager completed initial contact communication/notification with the governors' designees offices for the 10 States identified as on the expected route on February 10, 1986. Included were discussions related to issues that might exist and any special requirements. It became apparent that differing desires existed from State to State regarding advance information (see April 2, 1986, letter from James Thompson, Governor of Illinois, to Secretary John Herrington, Appendix G), and some States desired to meet for detailed discussions. Also, the notification action, coupled with media announcements discussed below, initiated considerable activity in the public sector in general. The TMI-2 program arranged to meet with those States requesting further discussion of details of the impending shipments and their requirements. These meetings were viewed as opportunities to resolve issues up front and included discussions of the rail route and measures being taken to ensure public safety (see May 16, 1986, letter from Secretary Herrington to James Thompson, Appendix G). Meetings were held at TMI-2 on April 24, June 4, and June 10, 1986, with transportation representatives of Pennsylvania, Illinois, and Missouri, respectively. Close working arrangements with the States would be a considerable aid to overcoming issues, and in retrospect, the program would have benefited by similar meetings with every involved State before the start of the shipments.

A status of State requirements as known to the program just before the start of the shipping campaign is shown in Table 2-5. However, unknowingly, the program was entering an arena beset by deficiencies. The governor's designee or other personnel contacted for preshipment notifications were not always the only State representatives who believed they should be personally notified, and depending on internal communications within the States, either for personnel notification or processing of information to communities, was unreliable. Accordingly, there were adjustments as the campaign progressed. The notification policy actually practiced by the program was to provide the seven-day prenotification along with frequent backup telephone calls until the train entered and left a State. A relatively high level of communication was established.

One outcome of meetings and other communications with the States, along with negotiations with the railroads, was the establishment of in-transit inspection locations and arrangements. The inspection locations and inspection frequencies are listed in Table 2-6 and were largely unchanged throughout the campaign. The inspections principally involved reviews of shipping papers and performance of radiation surveys.

Table 2-5. Notification, inspection, or other requirements of the States as known to the TMI-2 Program before the start of the shipping campaign.

State	Requirements
Pennsylvania	Notification for each shipment and briefings from time-to-time on developments; information meetings for local officials along the route. Also by agreement, contact with the following for each shipment: • Londonderry Township • Middletown mayor • Pennsylvania Emergency Management Agency • State Police • Pennsylvania Bureau of Radiation Protection • Pennsylvania Utilities Commission (if a problem arises).
Ohio	One to three days advance notification before each shipment
Indiana[a]	Notification before each shipment (designee's representative to notify State Police)
Illinois	Seven days advance notification; inspection rights; escort rights (also speed control and dedicated trains were requested)
Missouri	48-hour advance notification; request for designated DOE official for emergency response; requests for additional information on procedures and equipment
Kansas[a]	Notification when campaign starts
Nebraska[a]	Advance notification on each shipment
Colorado[a]	Notification when campaign starts
Wyoming[a]	Notification of each shipment
Idaho[a]	No requests

a. No evidence of a pending problem indicated by officials.

Table 2-6. Locations and frequency of State inspections.

State	Location	Frequency
Pennsylvania	TMI site	Random in conjunction with other inspecting parties
Ohio	Crestline, Ohio	Random
Indiana and Illinois	Indianapolis, Indiana, Avon Yards	Illinois entrance inspection
Illinois and Missouri	East St. Louis, Illinois	Illinois exit and infrequent Missouri entrance inspections
Kansas	Kansas City, Kansas	Infrequent
Other States	Not applicable	No inspections

More on State interactions and working relationships is provided under activities during the campaign.

2.10.2 Public Relations Strategy. Several months before the start of the campaign, DOE and EG&G Idaho developed a Public Information Plan.[43] The objective of this plan was to establish procedures and guidelines for communicating information to news media and the public on the TMI-2 core debris shipments in a straightforward and professional manner so that the public would have an accurate and full perception of the program. The communications effort was intended to eliminate or minimize concern and confusion that might result from lack of information or from incomplete or inaccurate information.

The following techniques were outlined in the plan:

- A single-source or point-of-contact was appointed to serve as spokesperson to news media, special interest groups, and the public and to assist with communications with State and local officials. A public relations professional from the Public Information Office of EG&G Idaho was appointed full-time to the position several months before the start of the campaign. The spokesperson attended all important meetings between DOE and EG&G Idaho and officials from GPU Nuclear, Conrail, UP, or the States. Also, the spokesperson was allowed relatively easy access to personnel of DOE-HQ in order to obtain DOE policy information firsthand.

- Informational meetings for public officials were planned in order to give State and local officials complete and factual information on the transport campaign. DOE decided to hold informational meetings only upon request because of the prohibitive expense and complexity of providing meetings for all public officials along the shipping route.

- Press conferences were planned in Pennsylvania and Idaho to provide news media with information regarding the campaign.

- Press releases were issued before the start of the campaign. The plan specified that press releases would be issued during the campaign if necessary.

- Information packages were prepared (see Appendix H for examples of materials in the packages) and hundreds of these were distributed both before and during the campaign. The informational packages contained both general and technical descriptions of the rail casks and transportation plans, a DOE policy booklet, and information on core debris handling, examination, and storage capabilities at the INEL.

- Videotapes were produced to describe key cask safety features and other aspects of the planned campaign, with versions for a general audience and versions for a more technical audience.

Although the plan originally allowed interested parties easy access to information about the campaign, the techniques would prove to be too reactive in nature. Several techniques were implemented in 1988 to become more proactive (see discussion in Section 3.5.1).

2.10.3 Media and Public Interactions Before Start of Campaign. Aside from the State interactions, DOE made a public announcement in February 1986 of the upcoming campaign to the NRC TMI-2 Citizen's Advisory Panel (a public group with authority to monitor TMI-2 cleanup progress). DOE also responded to requests for meetings from private individuals and elected officials, and in conjunction with GPU Nuclear, hosted a news media day at TMI on July 1, 1986. DOE displayed both a NuPac 125-B rail cask (Figure 2-34) and a scale model of the cask showing key safety features. DOE described the planned shipping campaign, and responded to questions during the media day. After the first shipment of core debris arrived at the INEL, DOE similarly held a press conference for the Idaho news media on July 24, 1986. As part of the return trip to TMI, the empty cask and scale model were displayed publicly in Blackfoot, Idaho, on August 3, 1986. The videos and documentation produced to describe key cask safety features and other features of the planned campaign were made available for viewing to various audiences throughout this period of time.

2.10.4 Emergency Preparedness/Emergency Response. Emergency preparedness and emergency response would be an issue throughout the transport campaign. The possible need for emergency action in response to some major event with a TMI-2 train was a subject with which States, cities, communities, elected and appointed officials, and the public in general could express concern and lack of experience, training, or equipment. It simply was not within the power of DOE or the shipping team to entirely eliminate this issue in the public sector, but considerable effort was made to address concerns through presentations, documentation, and workshops (see Section 3.5 for amplification on workshops and other discussions on this subject).

One effort was to provide information on DOE preparations for emergencies and the expected roles of various participants as follows:

- The primary role of a community and/or State emergency response organization, or officials, in the case of an event with a TMI-2 core debris shipment was to isolate the situation until assistance could arrive. The severity of the event should dictate how far the general populous might be excluded from the scene [generally 762 m (2,500 ft)].

- Rail personnel, in conjunction with their control centers, were required to notify DOE emergency centers, especially the INEL's Warning Communications Center, reporting the event in keeping with procedures in place for the campaign. These procedures were designed to disclose the situation as fully as possible. But community, State, or other officials could also notify DOE or any Federal emergency office to initiate the notification process.

- In response, DOE and other Federal agencies, such as the Federal Emergency Management Agency, had the role of providing assistance. DOE had an established Radiological Assistance Program with eight geographical regional offices and 26 teams that could mobilize in two hours and be at the scene of an accident within six to eight hours maximum. These teams were trained and equipped to provide a full range of radiological emergency assistance.

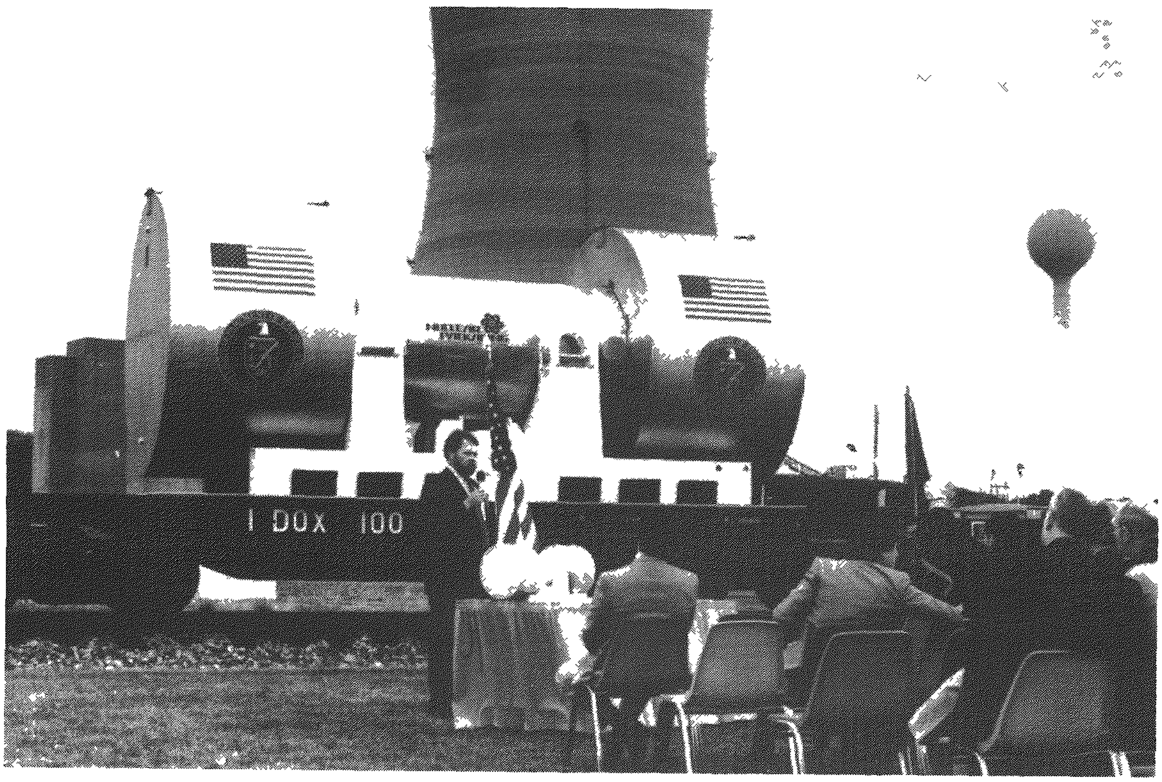

Figure 2-34. NuPac 125-B rail cask displayed to the news media on July 1, 1986

- For the TMI-2 campaign, DOE had established an Emergency Response Team at the INEL with the role of providing enhanced communication links between INEL management and the location of the event, assistance in radiological issues, radiological equipment, public information, definition of on-scene DOE responsibilities, security assistance if necessary, and facilitation of governmental assistance in recovery from the event The INEL team had prearranged air transport and pre-identified membership and instructions

- The rail companies had the role of accident recovery in accordance with established procedures for their activities in such an event They also had established plans for general notification, emergency procedures, exclusion guidelines, identification of equipment needed for recovery, recovery operations, and so forth

Needless to say, no major event occurred with a TMI-2 core debris shipment, such that most of the above was never implemented The only accident involving a TMI-2 train is discussed in Section 3 2 6, shipment number 7

3. CONDUCT OF THE TRANSPORT CAMPAIGN

The actual transport operations for the TMI-2 core debris shipments were typical of any large, complex project, with changes due to technical improvements, new requirements, and corrections of previous oversights. In addition, some changes were caused by the influence of public interactions with the shipping campaign.

Transport operations spanned from July 1986 to May 1990. This section will describe the preparations of canisters and loading of casks at TMI-2; the movements of the loaded and unloaded casks to and from TMI-2 and the INEL; receipt, unloading, and storage operations at the INEL; changes needed to contracts with major support organizations to accomplish the shipments; and an array of problems and issues caused by the institutional interest in the shipments.

3.1 Cask Loading at TMI-2

The loading of a NuPac 125-B cask at TMI-2 was a straightforward process with few unanticipated problems given the custom equipment that was provided to do the job. The task was broken into preparation of each canister for shipment, and then transfer of the prepared canisters into a cask.

The preparation of a canister for shipment was a process that started with approval by DOE-ID of the canisters designed by B&W and ended with a canister being lowered into the shipping cask at TMI-2. This process was tracked closely, with innumerable documents recording the performance of every activity and the associated quality control checks.

Fabrication of canisters was the initial step following approval of the designs. Because of the safety functions for criticality control and confinement of the radioactive core debris, canisters were fabricated under a demanding QA program and were classified as "Nuclear Safety Related," for operations at the TMI-2 facility. Each part of each canister was subject to strict controls during fabrication. Inspections were provided by the canister fabricator's QA personnel and subject to additional oversight by QA organizations from Bechtel, GPU Nuclear, EG&G Idaho, DOE, and NRC. Following receipt inspection at TMI-2 by GPU Nuclear, each canister was certified as meeting all applicable design, fabrication, and quality control requirements and ready to use. Additionally, a final inspection was performed on-site by EG&G Idaho, generally in conjunction with GPU Nuclear's receipt inspection.

Loading of a canister in the TMI-2 reactor vessel was an activity performed by GPU Nuclear's licensed operators. Detailed procedures were used that addressed the limits within which the operators could load material. Records of the loading of each canister were kept in log books and on videotape for loading of fuel canisters during pick-and-place defueling operations.

Following the defueling procedures helped ensure that EG&G Idaho's acceptance criteria for loading canisters would be met. These criteria included (a) an adequate description of the contents of each canister, (b) loading of only core materials (and certain EG&G Idaho approved non-core materials), (c) no damage to the canister, and (d) no off-normal events that would prevent the removal of a fuel canister's contents.

After the fuel canisters were loaded with core debris, heads were installed on the fuel canisters. Prior to removal from the reactor vessel, each canister of every type was weighed. All canisters were transferred from the vessel to the fuel transfer canal and out into the spent fuel pool in the TMI-2 side of the FHB.

In the spent fuel pool, several activities were performed to ready a canister for shipment. Canisters were weighed several times at separate points in the preparation process. Weighing ensured that canisters did not exceed the weight limits for a canister either for transport or for storage at the INEL. The weight limits applied to a loaded canister's weight in air following dewatering immediately before loading it into a cask.

The weight information was also useful in determining if a canister had been dewatered sufficiently using a gas displacement method for water removal. In this dewatering process, each canister was pressurized through the vent nozzle with an argon, helium, or nitrogen cover gas that forced water up an internal drain line and out the drain nozzle on the outside of the upper head. Following the dewatering process, each canister was required to have been dewatered to an extent that a sufficient quantity of catalytic recombiner in each canister would not have been submerged when the canister was in any orientation during transport. The canister dewatering criterion is discussed further in Appendix I, "Cask SAR Revisions." Although a few canisters had initial dewatering in the reactor vessel at the start of defueling, the dewatering operation subsequently occurred solely in the FHB. Weighing of canisters, for canisters submerged between dewaterings, was also an indication of any water inleakage into a canister.

The final pressure of a canister's cover gas after dewatering was left at approximately two atmospheres absolute (14.7 psig). This amount of pressure was sufficient to verify that a canister did not leak before loading it into a cask. After capping the nozzles, the upper head on each canister was watched for the formation of bubbles, which would have identified a leak of the cover gas past a seal.

Limiting the choice of cover gas to only argon, helium, or nitrogen, rather than air, had two purposes. One was to not introduce oxygen in air into a canister in recognition of the potential for the presence of pyrophoric materials. The second was to enable monitoring of radiolytic gas generation and functioning of the catalytic recombiners. These three cover gases allowed easy detection of oxygen produced as a gas by radiolysis of water, whereas the use of air as a cover gas would have introduced oxygen into a canister and prevented measuring an oxygen generation rate by analysis of a sample of a canister's gases. A sample of the gases in a canister were taken after dewatering, which allowed a net generation rate to be established for both hydrogen and oxygen. From the gas generation rates, the time to reach an unsafe concentration of combustible gases was determined and had to show that an unsafe concentration of combustible gas could not be reached from the time of cask closure through twice the expected shipment time. This was in keeping with the CoC for the shipping cask. From an operational standpoint, unloading of the cask had to occur before any combustible gas mixture could be generated. In practice, this was not a problem since gas generation rates were low. A discussion of monitoring canisters for gas generation performed at the INEL is provided in Section 3.3.4.4.

For some canisters, GPU Nuclear had to treat the contents and internal surfaces to control the growth of microorganisms. This resulted from microorganisms detected in the reactor coolant system as defueling activities progressed. For those canisters suspected of containing the microorganisms, GPU Nuclear developed and used procedures to ensure that damage would not occur to the integrity of affected canisters during long-term storage at the INEL.

Another step in the preparation of a canister for shipment was the decontamination of the external surfaces. An initial step was to spray a canister during removal from the reactor vessel before transfer to the spent fuel pool. After other preparations were completed, a canister was again sprayed while being raised into the fuel transfer cask before loading into a shipping cask. The INEL had set limits for loose external surface contamination of less than 10,000 disintegrations per minute (dpm) of beta and gamma emitters per 100 cm^2, and less than 250 dpm of alpha emitters per 100 cm^2. This limit was difficult to achieve for some canisters, as discussed in Section 3.3.3.11, and several adjustments to spraying and scrubbing were performed during the course of the campaign with the objective of improving decontamination effectiveness.

The lifting of a canister into the fuel transfer cask was the start of the canister handling portion of the cask loading process. As discussed in Section 2.6.1, the loading procedure involved bringing an empty cask into the truck bay, off-loading from the railcar, uprighting to vertical, removal of outer and inner vessel lids, and installation of the special cask loading equipment onto the top of a cask (see Figure 2-24).

3.2 Transportation Operations

In this section, the operations that ultimately evolved are described commencing with preshipment checklists and inspections; logistics, including type of service, number of casks per train, and train makeup; rail company operating procedures, speeds, and other restrictions; personnel considerations; summary of shipments and shipping incidents; weather during the campaign; shipping costs; maintenance activities during the campaign; and core contract and other contract changes.

3.2.1 Preshipment Checklists and Inspections. After reaching agreements between GPU Nuclear and EG&G Idaho regarding canister acceptance procedures, EG&G Idaho developed a plan to overview the performance of GPU Nuclear's operations in preparation of canisters for transfer to the INEL, including quality and safety issues associated with the transfers. The plan was designed to ensure that DOE requirements were met. The requirements were derived from the core contract, canister acceptance criteria, cask SAR, and DOE orders regarding quality and safety.[44] Checklists were developed to document and verify that the canister fabrication, loading during defueling, preparation for transport, loading into the cask, and transport requirements of DOE were met.[41] A summary of the operations, quality programs, and EG&G Idaho actions covered by the plan is presented in Table 3-1. A list of the checklists developed by EG&G Idaho to verify that the canisters and shipments were prepared in accordance with the DOE acceptance requirements is provided in Table 3-2.

One of the principal procedures used by GPU Nuclear to demonstrate to DOE that the INEL's canister acceptance requirements were met was TMI-2 Administrative Procedure 4200-ADM-3255.01, "Canister Vessel Traveller Data." The procedure was used to record specific information related to each defueling canister from delivery on-site, through use, storage, preparation for shipping, and finally, release for shipping off-site. The procedure was a data package of information retrieved from other operating procedures. Table 3-3 is a list of some of the procedures used by GPU Nuclear to prepare the canisters and casks for shipment.

EG&G Idaho used information contained in the Canister Vessel Traveller Data procedure to complete the preshipment checklists.[45] Once all of the items on the checklists were satisfactorily met, EG&G Idaho would accept the canisters and casks in a shipment for transport to the INEL. A manual with this information accompanied each shipment from TMI to the INEL.[46] EG&G Idaho also performed periodic inspections following the TMI Overview Checklist of GPU Nuclear's operations to verify that the information contained in the Canister Vessel Traveller Data procedure was accurate. Table 3-4 lists the overview checklists and frequency of inspections performed by EG&G Idaho.

Copies of the checklists for all 49 cask loads shipped to the INEL and the supporting documentation are available through the TMI-2 Documentation Data Base, located at the INEL Technical Library.

3.2.2 Transport Logistics

3.2.2.1 Type of Service. As discussed in Section 2.8.2, DOE agreed that the rail carriers would move the first three shipments via expedited service on a special train, whereby the only freight would be the TMI-2 cask(s). DOE originally had an objective of switching to regular freight service once some experience was gained through the initial shipments. However, Conrail was adamant on expedited service remaining a contractual requirement, and much of the public and many governmental officials eventually insisted upon this special train arrangement. GPU

Table 3-1. Operations, quality program plans, and EG&G Idaho actions.

Operation	Organizational quality programs	EG&G Idaho actions
Canister design	GPU Nuclear Recovery QA Program[a] Bechtel QA Program B&W QA Program	Reviewed and approved design specification and drawings for compliance with INEL canister acceptance requirements.
Canister fabrication	GPU Nuclear Recovery QA Program[a] Bechtel QA Program B&W QA Program NES QA Program Joseph Oat Co. QA Program	Performed first-article canister inspection checklist, and follow-up in some cases, at each vendor's facility for one of each type of canister. Performed reduced canister checklist at TMI for each subsequent canister fabricated.
Canister loading	GPU Nuclear Recovery QA Program[a]	Observed and inspected GPU Nuclear defueling operations at anytime and reviewed GPU Nuclear documentation to ensure compliance with canister loading acceptance requirements. Inspections were in accordance with written checklists prepared by EG&G Idaho and were performed on a periodic basis.
Canister preparations for shipping	GPU Nuclear Recovery QA Program[a]	Observed and inspected GPU Nuclear canister preparations for shipping at anytime and reviewed GPU Nuclear documentation to ensure compliance with canister preparations acceptance requirements. Inspections were in accordance with written checklists prepared by EG&G Idaho and were performed on a periodic basis.
Cask loading	GPU Nuclear Recovery QA Program[a]	Observed and inspected GPU Nuclear cask loading operations at anytime and reviewed GPU Nuclear documentation to ensure compliance with the cask loading acceptance requirements. Inspections were in accordance with written checklists prepared by EG&G Idaho and were performed on a periodic basis.
Cask transport	EG&G Idaho QA Program	Completed pretransport observations and documentation reviews to ensure compliance with transport requirements. Managed transport activities.
Cask receipt and unloading	EG&G Idaho QA Program	Performed cask receipt and unloading activities in accordance with detailed operating procedures at CFA and TAN.

a. Per 10 CFR 71, Subpart H and 10 CFR 50, Appendix B.

Table 3-2. Checklists prepared by EG&G Idaho for TMI-2 shipping activities.

Checklist title	Identification number	Frequency
TMI-2 Defueling Canister Source Inspection Instructions		
First article inspection—fuel canister (at vendor's facility)	AEB-001	One per vendor
First article inspection—filter canister (at vendor's facility)	AEB-002	One per vendor
First article inspection—knockout canister (at vendor's facility)	AEB-003	One per vendor
Reduced checklist—fuel, knockout, filter (at TMI facility)		One per canister
Checklist for Canister Loading—Defueling Operations	3.1	
Canister loading description completed	3.1.1	Each canister
Core material or approved noncore material only	3.1.2	Each canister
Video tapes transmitted to EG&G Idaho (if made)	3.1.3	Each canister
Off-normal events associated with canister identified (if any)	3.1.4	Each canister
Nonconformance reports closed out (if any)	3.1.5	Each canister
Checklist for Canister Preparations for Shipment		
Canister weight limit	4.1	
Canister weight	4.1.1	Each canister
Number of canisters >2,800 lb	4.1.2	Previous shipments
Number of canisters >2,800 lb	4.1.2	This shipment
Total number of canisters >2,800 lb	4.1.2	All shipments
Dewatering void volume	4.2	Each canister
Leak testing	4.3	Each canister
Gas control	4.4	Each canister
Canister contamination	4.5	Each canister
Hansen cap installation	4.6	Each canister
Canister microorganism control	4.7	Each canister
Detailed Checklist for Dewatering, Void Volume, and Leak Testing for Each Canister		
Dewatering, void volume and leak checklist	4.2	Each canister
Canister leak testing	4.3	Each canister
Gas monitoring checklist	4.4	Each canister
Checklist for Cask Loading and Preparation for Shipment		
Shipment information	5.1	Each shipment
Attachment checklists	5.2	Each shipment
Canister loading information	5.3	Each shipment
Loading diagram	5.4	Each shipment
ICV lid leak test	5.5	Each shipment
OCV lid leak test	5.6	Each shipment
Shipping cask assembly	5.7	Each shipment
Chain of Events to Ship TMI-2 Core Debris from TMI, Middletown, Pennsylvania to the INEL, Scoville, Idaho	—	Each rail shipment
Checklist for Shipping TMI-2 Core Debris to INEL and Return of Empty Cask (includes seven tables and two appendices)	—	Each cask load

Table 3-3. Table of TMI-2 operating procedures related to core debris shipping.

Procedure title	Identification number
Control of Lifting and Handling Program	4000-ADM-3890.02
Canister Vessel Traveller Data	4200-ADM-3255.01
Operations of In-Vessel Dewatering System	4210-OPS-3255.16
Fuel Handling Building Defueling Operations	4215-OPS-3255.01
Bolt Torquing and Sequences	4220-CMG-3900.05
Shipment and Transfer of the TMI-2 Fuel Canisters to DOE	4231-ADM-4450.04
Canister Handling and Closure Operation	4210-OPS-3255.08
NuPac 125-B Rail Cask Disassembly	4231-OPS-4450.15
NuPac 125-B Rail Cask Loading	4231-OPS-4450.16
NuPac 125-B Rail Cask Assembly	4231-OPS-4450.17
NuPac 125-B Maintenance Verification Leak Tests	4231-OPS-4450.18
NuPac 125-B Assembly Verification Leak Tests	4231-OPS-4450.19
Removal and Installation of NuPac 125-B Cask Cover and Overpacks	4231-OPS-4450.21
General Troubleshooting	4220-IMP-3032.01

Table 3-4. List of overview checklists used in periodic inspections performed by EG&G Idaho to verify TMI-2 core debris shipping activities.

Checklist title	Identification number	Frequency of inspections
Canister Dewatering	1	Quarterly
Canister Empty Weight—Traveller Check	2	Quarterly
Fuel Handling Building Weighing Device Accuracy	3	Quarterly
Empty Canister Weight and Weighing Device Accuracy	4	Quarterly
Canister Leak Test/Hansen/Pipe Nipple Inspection	5	Quarterly
Canister Heat Load Calculation	6	Quarterly
Canister Gas Sampling at TMI	7	Quarterly
Canister Microorganism Kill	8	Quarterly
Canister External Decontamination	9	Quarterly
Canister Transfer—Storage Pool to Cask	10	Quarterly
Defueling Daily Surveillance	11	Weekly
Cask Inner Vessel Preparations	12	Quarterly
Cask Outer Vessel Preparations	13	Quarterly
Cask Preparations—Outside Truck Bay	14	Quarterly
Source Document Verification (completeness and data adequacy)	15	Quarterly
Special Overview	16	When needed

Nuclear concluded that the service could contribute to meeting their defueling schedule and entered into agreement with DOE to pay for the service. Accordingly, DOE was able to agree to a continuation of this service, and the additional charges, without prejudicing DOE's ongoing litigation with the nation's railroads.

3.2.2.2 Train Makeup and Number of Casks. For the initial single cask shipment, the flat car carrying the cask was situated between two empty gondola cars. Subsequently, these cars were loaded with ballast (crushed rock) for increased stability. For the double cask shipments, the two casks were located alternately between three gondola cars (Figure 3-1). The remaining equipment for a TMI-2 shipment consisted of one or more diesel locomotives and a caboose. The requirement for a caboose derived from additional personnel aboard the train (see Section 2.8.3 for initial considerations regarding need for caboose and Section 3.2.4 for further considerations). Cabooses were an issue throughout the campaign. The use of cabooses in the rail industry is rapidly disappearing and those still in service are dated or of questionable accommodations, certainly never built for comfort. Negotiations at the start of the campaign and subsequently for possible use or acquisition of an executive car or specially outfitted caboose were unsuccessful.

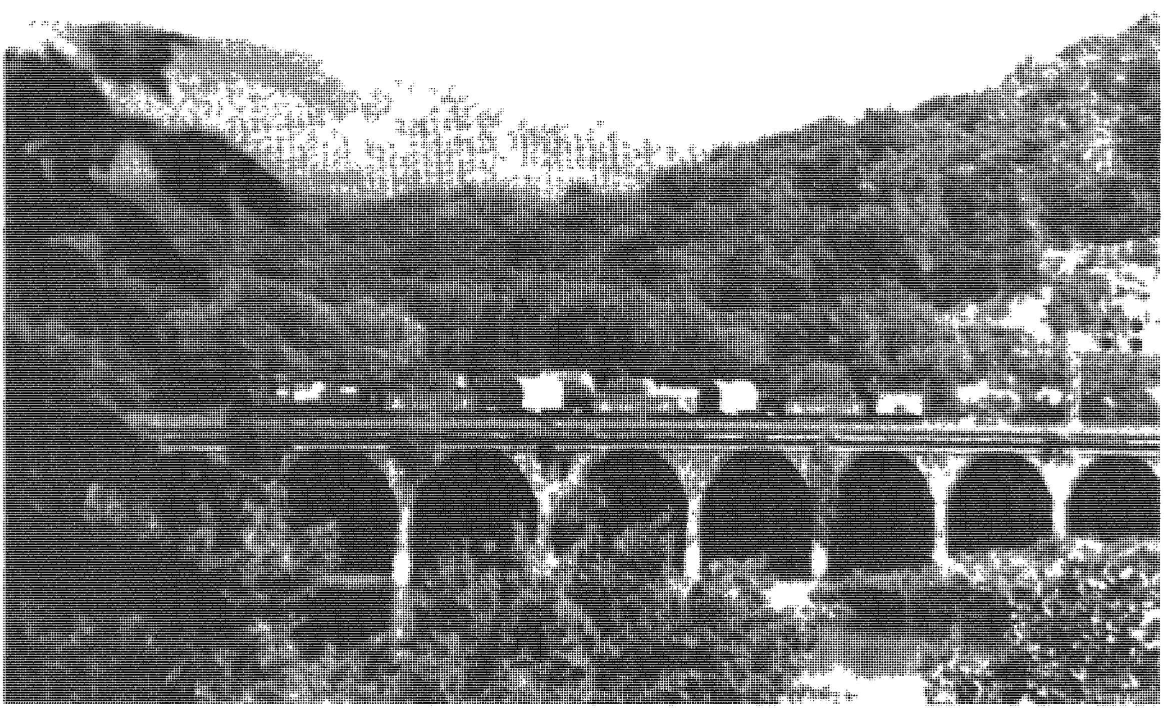

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Figure 3-1. Double cask shipment, using three gondola cars.

Originally, the TMI-2 Program planned to use only two casks; however, in 1986, GPU Nuclear opted to lease a third cask from Nuclear Packaging in response to GPU Nuclear's projection of shipping needs related to keeping the defueling effort on schedule. The third cask was fabricated and placed in service in November 1987. In December 1987, all three casks were used for the first time in one shipment to the INEL (the 13th rail shipment, see Figure 3-2; also see Section 3.5.2, item 6, for interaction with the public related to the use of three casks).

88-30-1-2

Figure 3-2. Triple cask shipment, leaving TMI.

Prior to the day of shipment, Conrail prepared and inspected equipment to be used in making up the train; the cask railcars were inspected at the TMI site, and other cars and equipment were inspected at Conrail's railyards near Harrisburg. On the day of the shipment, all equipment was inspected again by the rail company and by the FRA. If a minor problem was found, the FRA allowed the train to go to the Harrisburg yards for repair. Any significant finding would have prevented the shipment from proceeding. Additionally, on or before the day of the shipments, inspections of the train or various aspects of the shipment were performed by DOT, NRC, EG&G Idaho, and GPU Nuclear.

3.2.3 Rail Company Conduct of Operations. As stated in Section 2.8.3, EG&G Idaho and DOE did not become involved in either rail company's conduct of operations except in the overview sense or for special issues involving contractual negotiations or interfaces with the public. Examples of operational issues that were negotiated included State inspection arrangements, any-day pickup of shipments at TMI-2, time-of-day transit through St. Louis, and train makeup.

The Conrail and UP operating instructions issued for the first TMI-2 shipment and basically adhered to throughout the campaign were as indicated in Table 3-5.

As a measure of Conrail's policy of stopping the TMI-2 train for oncoming traffic, the train stopped 39 times for 46 trains to pass on one typical trip from Middletown, Pennsylvania, to East St. Louis, Illinois. The total time the TMI-2 train was stopped was 10 hours and 19 minutes, an average of 15 minutes per train encountered.

With regard to Conrail's policies on speed restrictions, Sunday-only pickup, and stopping for other trains, it can be noted that there was opinion that these policies seemed to seriously depart from, and in some ways defeat, the concept of expedited service. There were communications from GPU Nuclear to DOE to initiate requests to Conrail for "any-day or random" service to pick up TMI-2 shipments. Any-day pickup was viewed by GPU Nuclear to be an option that could enhance the defueling and shipping schedule. The utility could save large amounts of funds by earlier defueling and facility licensing changes. Casks that might not be ready for a Sunday-only pickup might be ready on a Monday or Tuesday, for example. And the utility considered they were paying for expedited service, which should include pickup of shipments upon request. DOE agreed to request Conrail to provide for any-day service. Conrail denied this largely from an operating standpoint in that Sunday afternoon and Monday were their lowest traffic volume periods of each week on the route and any-day pickup would expose the TMI-2 train to a considerably larger volume of traffic.

3.2.4 Personnel Considerations

3.2.4.1 Train Crews and Crew Changes. The original route, schedule, and crew change points for the TMI-2 transport campaign are shown in Table 2-4. Crew change points are also shown in Figure 2-33. Adjustments to this schedule would occur as the campaign progressed in response to public concern regarding transit through St. Louis during rush hours (see discussions Section 3.2.6) and as a result of operational efficiency improvements. Some trains would leave TMI-2 earlier than indicated and similarly some would arrive at Scoville earlier, but the route and crew change points would remain effectively unaltered for the entire campaign. As indicated in the table, Conrail used six crews, with changes at Harrisburg, Altoona, and Conway, Pennsylvania; Crestline, Ohio; and Indianapolis, Indiana. UP started at East St. Louis, Missouri, and used eight crews with changes at Jefferson City, Missouri; Kansas City, Kansas; Marysville, Kansas; North Platte, Nebraska; Cheyenne, Rawlins, and Green River, Wyoming; and Pocatello, Idaho. Nominally, therefore, most of the rail train crews were on board for six- to eight-hour shifts.

Table 3-5. Operating instructions for Conrail and UP.

Conrail	UP
Train crew must have shipping papers and all hazardous material instructions for this commodity in their possession at all times	Same as Conrail
Train speed is not to exceed 30 mph	Allowed to travel at regular train speeds
Train must stop when meeting or being passed by other trains	Not required
Train must be inspected, on both sides, immediately upon stopping	No special instructions
Trains meeting or passing this special train must not exceed 40 mph while passing	Not required
Train must be accompanied by road foreman	Not required
Train must be accompanied by Conrail security officer	Not required
Train must receive continuing surveillance throughout movement, by train crew and supervisory officers	Continuous surveillance by train crew only
Train must receive continuing surveillance while in yards and terminals	Same as Conrail
Should there be any derailment or incident enroute, immediate telephone report must be made to Conrail's Systems Operations Bureau (Control Center)	Report to UP's Control Center
Hourly passing reports must be made, via normal channels, to Conrail's System Operations Bureau (Control Center)	Every four hours

In addition to the road foreman and security officer, as identified in the Conrail operating instructions above, the Conrail train crew included a conductor, an engineer, and a mechanic (fireman\brakeman). UP generally used only an engineer, a conductor, and a mechanic.

Exceptions and changes to the crew changes and schedule above would occur as a result of public interaction. Subsequent agreements were needed in response to the issue of three casks on one train (see Section 3.5.2, item 6).

3.2.4.2 DOE Representatives. Part of the agreements between DOE and the rail companies at the start of the campaign was for DOE representatives to accompany the first three TMI-2 shipments. Subsequently, starting with the 14th rail shipment, a DOE representative was on board for every shipment as part of the agreements reached between Senator Danforth, Missouri, and DOE Secretary Herrington (see Section 3.5.4.2, "Federal Railroad Administration Investigation"). This function was manned by EG&G Idaho employees who in general were closely related to the TMI Program. For the initial three shipments, this representative was to record "time and motion" data to establish a baseline for operations and to evaluate improvements. The representative did not have authority over any of the rail operations, although in a few cases, the representative was considered an authority on the activity in general. To overcome the potentially overwhelming logistics of this function, EG&G Idaho management authorized these personnel for extended work conditions. A typical worker was required to have a medical release, be trained in the use of radiation detection equipment in case of some event, sign a liability release ("hold harmless agreement") for the rail companies, and have a briefing on the transportation action. Such workers would fly from Idaho to TMI before the shipment and ride in the caboose of the train to East St. Louis, a period of about 48 hours. He would be met by a replacement who had flown to St. Louis, and would accompany the train for the remainder of the trip, again about 48 hours. Whereas rail crews were changed out after shifts of about eight hours, the DOE representatives endured much longer shifts in a caboose, generally with whatever food they carried aboard and marginal accommodations.

3.2.4.3 Inspection Personnel. As part of negotiations with the States, inspection locations for the TMI-2 shipments were established as shown in Table 2-6. A copy of an inspection report from the City of St. Louis is provided in Appendix G. State personnel associated with these inspections were sometimes numerous and not always fully identifiable as to discipline or function. A typical organization was the Illinois Department of Nuclear Safety. The best description of their activities is that they attempted to detect radiation levels, reviewed shipping papers, and generally observed operations.

Entrance inspections for the State of Illinois were performed at Indianapolis, Indiana. Typically, or often, the safety inspector from the State of Illinois would board the train at Indianapolis, and upon arrival at the State line near Terra Haute (Indiana), the inspector would establish shortwave radio communications with an escort vehicle from the Illinois Highway Patrol. Continuous communications were maintained with the escort to East St. Louis. One observation of this process was that the operator and personnel in the escort vehicle were in a highly hazardous endeavor because of the high vehicle speeds required to maintain proximity to the train on roadways that often took a divergent path from the railroad tracks.

3.2.4.4 Monitoring/Communications Personnel. In addition to personnel identified above, a number of personnel were involved with tracking the TMI-2 trains. After a train with loaded casks exited the TMI-2 site, a Conrail engineer (or conductor) was required to communicate hourly passing reports to Conrail's control center, and UP's engineer reported at least once every four hours until arrival at the INEL. The control center for Conrail was located in Philadelphia (Pennsylvania), while that for UP was located in Omaha (Nebraska). Each time an engineer communicated, the dispatcher was informed of a train's exact location and information about any unusual occurrence. In turn, the control center relayed the same information on approximately four-hour intervals (maximum of six hours) by telephone to the Warning Communication Center of DOE and the traffic manager of EG&G Idaho at the INEL. While a train was in motion, the control center monitored, by computer, the speed and location of the train and the presence of nearby trains using the same track system. The control center knew the location of the train at any particular point in time. Besides talking with the control center, an engineer and/or conductor regularly communicated by radiotelephone with other rail personnel aboard the train. Accordingly, a sizeable number of personnel were tracking the progress of every shipment.

3.2.5 Physical Protection for TMI-2 Core Debris Shipments. Physical protection for a TMI-2 core debris shipment was required due to the special nuclear material present in the core debris. Requirements for adequate physical protection were carefully evaluated before the start of the shipping campaign. Procedures were developed to comply with, or exceed, all known applicable DOE policy requirements in effect at that time. A further evaluation was performed in May 1989 to ensure compliance with the then new DOE Order 1540.4, "Physical Protection of Unclassified Irradiated Reactor Fuel in Transit."[47] This evaluation disclosed that the program continued to be in compliance (see Don Ofte to J. O. Zane, letter dated June 9, 1989, Appendix G).

Describing all features of DOE's physical protection requirements and the means used to ensure compliance for a shipment of TMI-2 core debris during preparation, transit, receipt, and storage would be too extensive to include in this document. Accordingly, only the highlights are discussed below. A comprehensive document on physical protection during the TMI-2 shipments is available (entry 007028767 in the TMI-2 Documentation Data Base at the INEL Technical Library).

3.2.5.1 Physical Protection at TMI. Once loaded with canisters containing TMI-2 core debris, a shipment of one or more NuPac 125-B casks was placed in an on-island holding area awaiting shipment. TMI is an NRC-licensed facility with security-controlled access and NRC-approved physical protection plans. No additional comments are provided in this report regarding physical protection for the loaded casks while at TMI.

3.2.5.2 Physical Protection in Transit (Highlights of Applicable DOE 1540.4 Requirements and Means to Ensure Compliance).

1. **Requirement**—Routing via rail shall give consideration to the class of railroad, class of track, reducing time in transit, time at interchange points, number of carriers, and cost of service.

   Compliance—As indicated in this report, selection of the route between TMI and the INEL was based on the criteria mentioned above.

2. **Requirement**—The governor or the governor's designee shall be notified prior to the transport of unclassified irradiated fuel within or through a State.

   Compliance—The governor or the governor's designee was notified before the transport of TMI-2 core debris within or through each State.

3. **Requirement**—A carrier's communications center at a designated location will be staffed continuously by at least one individual who will monitor the progress of the irradiated reactor fuel shipment and will notify DOE and other appropriate agencies if an emergency should arise.

   Compliance—Both carriers had communication centers that were manned 24 hours per day. Instructions for train crews accompanied each shipment. These instructions told the train crew to notify EG&G Idaho's Warning Communication Center every four hours (maximum six hours) or immediately for any schedule delay. This communication was routinely made through the carrier's communication center.

4. **Requirement**—Carrier has emergency response procedures that are to be implemented as required.

   Compliance—Each carrier had its own emergency response procedures. In addition to those procedures, emergency response instructions were provided to the train crew by EG&G Idaho.

5. **Requirement**—For each irradiated reactor fuel shipment, a written log by the shipper and receiver is prepared that includes information describing the shipment and significant events that occurred and were reported or recorded by the escort during the shipment, and the conditions/inventory of the shipment received. Any significant events or unusual circumstances involved in receipt of the shipment should be included. These logs are to be available for review by authorized DOE personnel for a period of at least two years following completion of the shipment.

   Compliance—Since EG&G Idaho, acting on behalf of DOE-ID, was both the shipper and the receiver, the log was maintained at the INEL.

6. **Requirement**—Advance written notification, at least seven days in advance, to the governor or the governor's designee of each State through which the shipment passes in accordance with DOE 1540.1. Governors may, at their option and expense, choose to inspect the highway or rail transport vehicle, provided the vehicle is not unduly delayed, and to have law enforcement officers escort shipments through their jurisdictions.

   Compliance—This notification was made as described in Item 2, Compliance, above. Written prenotification was made seven days in advance along with follow-up telephone calls. In addition, checklists were used by EG&G Idaho to ensure that the required inspections were properly coordinated and resulted in minimal delay to the shipments. For example, a set of shipping-related documents was given to the train crew to give to the Illinois inspection team. The documents assisted the Illinois team in inspecting the shipments before entry into Illinois and helped to minimize delays.

7. **Requirement**—Shipment planning to ensure scheduled intermediate stops are minimized to the extent practicable.

   Compliance—The use of dedicated special train services provided the primary assurance that the intermediate stops were minimized. Additional assurance was provided by (a) issuance of a schedule, which was monitored very carefully by EG&G Idaho Traffic personnel, (b) coordinating inspections by the States, and (c) instructions to the rail crew to notify the EG&G Idaho Warning Communication Center of any schedule delay.

8. **Requirement**—At least one escort with appropriate communication equipment to maintain visual surveillance of the shipment during periods when the transport vehicle is stopped.

   Compliance—Both rail carriers provided the required escort. The requirement for the TMI-2 shipments was that each rail carrier would provide for continuous (sometimes called constant) surveillance of the cask(s) at all times. This was further defined as meaning that each carrier would provide personnel, other than the engineer, who would continuously have the capability to visually observe the cask railcar(s) while enroute. In addition, while a train was stopped in yards or terminals, special agents or supervisory personnel of the carrier continuously viewed the cask railcar(s), and stated personnel were instructed, if developments occurred that required additional attention, to implement appropriate emergency response procedures and immediately notify State, local, and Federal emergency response personnel.

9. **Requirement**—DOE may, at its option, assign a health physicist or another professional to accompany rail shipments to advise or assist the escort in an emergency, as requested. These employees may be required to execute a hold-harmless agreement per Rule 43 of the Uniform Freight Classification.

   Compliance—Shipments 1 through 3 and 14 through completion had an EG&G Idaho employee aboard the train to provide information about the shipments and to assist in an emergency, if required. These employees were required to execute a hold-harmless agreement, have a medical review, have training, and have management release on work duration restrictions.

3.2.5.3 Physical Protection Upon Receipt at the INEL. INEL Security personnel met the TMI-2 train upon delivery to the Scoville Siding and stayed with the shipments until pickup by the INEL locomotive and delivery to CFA. Once on the INEL site, the casks and contents were under the INEL security umbrella (e.g., controlled access and patrolled).

3.2.5.4 Physical Protection at TAN. The TMI-2 core debris upon transport to the TAN complex resides under the physical security plan for that facility. No discussion of that security plan is provided in this report.

3.2.6 Summary of Shipments and Shipping Incidents. The TMI-2 shipments were initiated on July 20, 1986, and were completed on May 9, 1990. There were a total of 49 cask loads transported by 22 rail shipments. Cask load 47 contained only six canisters, for a total of 342 canisters of TMI-2 core debris transported to the INEL. Table 3-6 provides a summary of the TMI-2 core debris cask loads and shipments. Note that cask load 1 corresponds to rail shipment 1, a single cask shipment, whereas cask loads 2 and 3 correspond to rail shipment 2, a two-cask shipment. As evident from shipping dates from TMI-2 and arrival dates at the INEL, the cross-country trip required about four days (several hours less than four days as operational efficiencies improved).

Insights into the shipping campaign can be obtained by reviewing the incidents that occurred during the 22 shipments. Information on each incident is as follows:

Shipment Number 1. The first TMI-2 shipment entered St. Louis about 8 a.m. on July 22, 1986, and a few St. Louis officials complained about entry during rush hours. The shipment was ordered stopped later that same day at the Kansas-Nebraska border (actually held at Marysville, Kansas) by Governor Kerry of Nebraska, who contended that the State failed to receive prior notification of the shipment from DOE. The train was held up approximately four hours while the issue was being resolved. The DOE representative aboard the train was requested to accompany officials to local State offices to explain the DOE action, which eventually led to releasing the train to proceed. The incident received national publicity. In actuality, the State of Nebraska had been notified of the shipment on July 18, 1986, and the impending shipments had previously been discussed with Nebraska officials on February 10, July 11, and July 14, 1986. However, the newly designated (July 1, 1986) governor's designee was not identified by the "old guard" as the person to receive notifications—an internal State communications breakdown. DOE received considerable loss of credibility, and there were no news media articles to set the record straight. However, the EG&G Idaho traffic manager and campaign spokesperson learned to very closely track changes in States' personnel resulting from elections or other events to avoid any further disruptions.

Shipment Number 2. This shipment faced prospect of delay (or minor rerouting) because of a UP freight train derailment on a bridge near Marysville, Kansas, on September 1, 1986. However, the bridge was repaired and inspected by the FRA per agreement with Kansas Governor Carlin by the time the shipment reached Marysville, and the TMI-2 train was not delayed. The shipment received significant news media attention in Missouri, Kansas, and Nebraska because of the bridge problem.

Shipment Numbers 3, 4, 5, and 6. These shipments entered St. Louis at 1:05, 4:45, 5:28, and 3:25 a.m., respectively. Each shipment was uneventful and received very little news media attention.

Shipment Number 7. This shipment entered St. Louis about 4:52 a.m. on March 24, 1987. The only accident involving a TMI-2 train occurred with this shipment, when the train locomotive struck a stalled automobile at a grade crossing in the City of St. Louis. The accident happened at a crossing protected by both flashing lights and a bell. The driver of the automobile ignored the lights and bell and proceeded into the path of the oncoming train. Once on the tracks, the driver saw the headlight of the locomotive and attempted to reverse his vehicle. The locomotive damaged the left front of the car but did not injure the driver. Investigation proved that the grade crossing warning devices were operating properly at the time of the accident and that the train was moving at the proper speed. The driver of the automobile was cited. The train sustained no damage but was delayed about one-half hour for inspections. The shipment received national news media attention because of the collision.

Table 3-6. Summary of core debris shipping campaign.

Cask load number	Rail shipment number	Cask identification number	TMI shipping date	Arrival at the INEL	Arrival at TAN	Return to CFA	Leave the INEL	Arrival at TMI	Accumulated number of canisters
001	001	2	20-Jul-86	24-Jul-86	25-Jul-86	30-Jul-86	02-Aug-86	12-Aug-86	7
002	002	1	31-Aug-86	04-Sep-86	11-Sep-86	23-Sep-86	27-Sep-86	09-Oct-86	14
003	002	2	31-Aug-86	04-Sep-86	05-Sep-86	11-Sep-86	13-Sep-86	26-Sep-86	21
004	003	1	14-Dec-86	17-Dec-86	30-Dec-86	08-Jan-87	10-Jan-87	23-Jan-87	28
005	003	2	14-Dec-86	17-Dec-86	18-Dec-86	22-Dec-86	23-Dec-86	30-Dec-86	35
006	004	2	11-Jan-87	14-Jan-87	17-Jan-87	21-Jan-87	24-Jan-87	04-Feb-87	42
007	005	1	01-Feb-87	04-Feb-87	06-Feb-87	12-Feb-87	14-Feb-87	26-Feb-87	49
008	006	2	15-Feb-87	18-Feb-87	20-Feb-87	25-Feb-87	28-Feb-87	07-Mar-87	56
009	007	1	22-Mar-87	26-Mar-87	03-Apr-87	09-Apr-87	11-Apr-87	20-Apr-87	63
010	007	2	22-Mar-87	26-Mar-87	27-Mar-87	02-Apr-87	04-Apr-87	16-Apr-87	70
011	008	1	21-Jun-87	25-Jun-87	26-Jun-87	30-Jun-87	03-Jul-87	10-Jul-87	77
012	008	2	21-Jun-87	25-Jun-87	01-Jul-87	07-Jul-87	09-Jul-87	15-Jul-87	84
013	009	1	26-Jul-87	30-Jul-87	31-Jul-87	04-Aug-87	08-Aug-87	19-Aug-87	91
014	009	2	26-Jul-87	30-Jul-87	05-Aug-87	12-Aug-87	15-Aug-87	26-Aug-87	98
015	010	1	13-Sep-87	17-Sep-87	18-Sep-87	23-Sep-87	26-Sep-87	03-Oct-87	105
016	010	2	13-Sep-87	17-Sep-87	24-Sep-87	28-Sep-87	03-Oct-87	10-Oct-87	112
017	011	1	25-Oct-87	29-Oct-87	29-Oct-87	03-Nov-87	07-Nov-87	15-Nov-87	119
018	011	2	25-Oct-87	29-Oct-87	03-Nov-87	12-Nov-87	14-Nov-87	24-Nov-87	126
019	012	3	15-Nov-87	19-Nov-87	19-Nov-87	24-Nov-87	28-Nov-87	08-Dec-87	133
020	013	2	20-Dec-87	24-Dec-87	28-Dec-87	01-Jan-88	02-Jan-88	09-Jan-88	140
021	013	3	20-Dec-87	24-Dec-87	04-Jan-88	07-Jan-88	09-Jan-88	18-Jan-88	147
022	013	1	20-Dec-87	24-Dec-87	07-Jan-88	13-Jan-88	16-Jan-88	27-Jan-88	154
023	014	1	07-Feb-88	11-Feb-88	16-Feb-88	18-Feb-88	20-Feb-88	27-Feb-88	161
024	014	3	07-Feb-88	11-Feb-88	11-Feb-88	16-Feb-88	17-Feb-88	24-Feb-88	168
025	014	2	07-Feb-88	11-Feb-88	18-Feb-88	22-Feb-88	27-Feb-88	07-Mar-88	175

Table 3-6. (continued).

Cask load number	Rail shipment number	Cask identification number	TMI shipping date	Arrival at the INEL	Arrival at TAN	Return to CFA	Leave the INEL	Arrival at TMI	Accumulated number of canisters
026	015	3	10-Apr-88	14-Apr-88	25-Apr-88	28-Apr-88	30-Apr-88	09-May-88	182
027	015	1	10-Apr-88	14-Apr-88	14-Apr-88	20-Apr-88	21-Apr-88	27-Apr-88	189
028	015	2	10-Apr-88	14-Apr-88	20-Apr-88	25-Apr-88	26-Apr-88	03-May-88	196
029	016	2	22-May-88	26-May-88	10-Jun-88	16-Jun-88	18-Jun-88	25-Jun-88	203
030	016	3	22-May-88	26-May-88	16-Jun-88	22-Jun-88	25-Jun-88	03-Jul-88	210
031	016	1	22-May-88	26-May-88	23-Jun-88	28-Jun-88	02-Jul-88	11-Jul-88	217
032	017	1	18-Dec-88	22-Dec-88	03-Jan-89	12-Jan-89	14-Jan-89	25-Jan-89	224
033	017	3	18-Dec-88	22-Dec-88	16-Jan-89	18-Jan-89	21-Jan-89	27-Jan-89	231
034	017	2	18-Dec-88	22-Dec-88	18-Jan-89	24-Jan-89	28-Jan-89	06-Feb-89	238
035	018	1	19-Feb-89	23-Feb-89	01-Mar-89	07-Mar-89	11-Mar-89	18-Mar-89	245
036	018	2	19-Feb-89	23-Feb-89	07-Mar-89	13-Mar-89	18-Mar-89	28-Mar-89	252
037	018	3	19-Feb-89	23-Feb-89	23-Feb-89	01-Mar-89	04-Mar-89	12-Mar-89	259
038	019	2	18-Jun-89	22-Jun-89	22-Jun-89	28-Jun-89	01-Jul-89	08-Jul-89	266
039	019	3	18-Jun-89	22-Jun-89	28-Jun-89	07-Jul-89	08-Jul-89	15-Jul-89	273
040	019	1	18-Jun-89	22-Jun-89	10-Jul-89	13-Jul-89	15-Jul-89	23-Jul-89	280
041	020	1	13-Aug-89	16-Aug-89	17-Aug-89	23-Aug-89	26-Aug-89	31-Aug-89	287
042	020	3	13-Aug-89	16-Aug-89	24-Aug-89	30-Aug-89	01-Sep-89	07-Sep-89	294
043	020	2	13-Aug-89	16-Aug-89	31-Aug-89	07-Sep-89	09-Sep-89	18-Sep-89	301
044	021	1	17-Dec-89	21-Dec-89	01-Feb-90	07-Feb-90	17-Feb-90	24-Feb-90	308
045	021	2	17-Dec-89	21-Dec-89	11-Jan-90	31-Jan-90	03-Feb-90	10-Feb-90	315
046	021	3	17-Dec-89	21-Dec-89	13-Feb-90	20-Feb-90	24-Feb-90	05-Mar-90	322
047	022	3	15-Apr-90	18-Apr-90	19-Apr-90	25-Apr-90	28-Apr-90	06-May-90	328
048	022	2	15-Apr-90	18-Apr-90	02-May-90	09-May-90	Cask stored	—	335
049	022	1	15-Apr-90	18-Apr-90	25-Apr-90	02-May-90	Cask stored	—	342

Shipment Number 8. The TMI-2 train was intentionally delayed before entering Missouri because of a fire near the railroad tracks in East St. Louis. Accordingly, the train entered St. Louis about 9:30 a.m. on June 23, 1987. St. Louis officials complained about the time of day the train passed through the city, but the shipment received little media attention.

Shipment Numbers 9, 10, 11, and 12. These shipments were mostly uneventful with little media attention. All shipments entered St. Louis by 7:00 a.m. or earlier.

Shipment Number 13. This was the first three-cask shipment. The train entered St. Louis about 7:10 a.m. on December 20, 1987. City officials and Missouri Governor Ashcroft complained about the train passing during rush-hour traffic. Some public and some city officials complained about three casks on one train (more hazardous in their opinion). This shipment received significant news media attention in the St. Louis area.

Shipment Number 14. This triple-cask shipment entered St. Louis about 8:30 a.m. on February 9, 1988. City officials and Governor Ashcroft complained about the rush-hour issue and excessive train speed (excessive speed unverified). Changeout of a defective buffer car in East St. Louis resulted in an incorrectly placarded car being placed on the train. This shipment received significant news media attention in St. Louis and other areas along the route because of the improper placarding and the time-of-day issue (see Section 3.5.4.2, "Federal Railroad Administration Investigation"). The city was primed for a major reaction as the result of a January 27, 1988, freight train derailment on the UP mainline on a bridge west of St. Louis. News media in the St. Louis area covered the accident using the approach, "What if this were a TMI-2 train?"

Shipment Number 15. This shipment was mostly uneventful; there was not a problem with rush-hour restrictions for this shipment or any subsequent shipment, except for the 21st shipment (see below).

Shipment Number 16. This shipment was uneventful except for the following. The UP caboose placed on the train at Indianapolis was reported unacceptable by the DOE representative upon being relieved at East St. Louis (no water, no toilet facilities, no heat, and dirty). EG&G Idaho's traffic manager reported the same to UP management, who investigated and concluded that conditions on the caboose were as reported or worse. Arrangements were made to correct the situation in Kansas City, Kansas. However, the problems with the caboose could not be corrected, and a second caboose was added to the train. At approximately 12:45 p.m. on May 25, 1988, the UP brakeman observed a person in the vacated caboose. Investigation disclosed that a transient (hobo) and small dog had slipped aboard at North Platte, Nebraska, or subsequently (Cheyenne, Rawlins, or Green River, Wyoming). The transient was evicted at Granger, Wyoming. This event served to cause UP to review caboose-use procedures and to dedicate improved units to the TMI-2 trains. Security was also further evaluated and reviewed. The transient was occupying the caboose previously used by the FRA, DOE representative, and UP personnel; there was no measurable radiation exposure hazard to the individual from his time aboard the caboose.

Shipment Numbers 17 and 18. These shipments were mostly uneventful.

Shipment Number 19. Because of a train derailment at Marse, Idaho, this shipment was diverted at Granger, Wyoming, to enter Utah at Wahsatch, proceed to Ogden, and from Ogden to McCammon, Idaho. This was the only instance of rerouting of a TMI-2 train. Short-turnaround notification was required to the State of Utah and concurrence was received on a same-day basis.

Shipment Number 20. This shipment was mostly uneventful.

Shipment Number 21. UP was required to replace a defective locomotive on this shipment after the initial locomotive quit several times. There was a wait before entering St. Louis because of the rush-hour passage restriction. A caboose battery was replaced to correct a lighting deficiency in the caboose. The caboose triggered a trackside heat sensor (rolling stock bearings high heat sensor) when it detected a higher-than-normal temperature reading on the front axle of the caboose. The train was stopped for inspection of the axle, and the belt that turns the generator to charge the battery on the caboose was found to be spinning around the generator pulley. The belt was cut and removed. The FRA inspected a large freight train (more than 100 cars) on trackage in front of the TMI-2 train, which resulted in an approximate three-hour delay.

Shipment Number 22. A changeout of the Conrail locomotive was required shortly after leaving Harrisburg (Pennsylvania), just before the Rockville Bridge, because of an electrical problem in the generator portion of the diesel-electric locomotive. The locomotive was newly overhauled and just out of the shops. A pickup locomotive moved the train to a siding while a replacement locomotive was being delivered. A delay of two to three hours was encountered.

3.2.7 Weather Conditions During Operations. So far, there has been no mention of weather conditions during operations. Since the campaign covered most of four years with transport operations mounted essentially without seasonal considerations, the shipments proceeded under almost every weather condition imaginable. Railroad guidelines included reduced speeds in high winds and other severe weather conditions. For very low temperatures, diesel fuel for locomotives can thicken to cause problems. The TMI-2 trains passed through a number of blizzards and mountain passes with heavy snow. The train was preceded by a snow plow on a few occasions. There is no record that weather caused more than minor delays to any transit during the campaign.

The lack of major delays resulting from weather during receipt and storage operations at the INEL was welcomed by workers in the program. INEL winters are historically severe with snow and icy road conditions often extending over the better part of three winter months. However, Idaho was experiencing the beginnings of severe drought conditions during the shipping campaign years, and road conditions were much better than could have been expected historically. Additionally, considerable "good fortune" seemed to attend the receipt operations. Storms seldom occurred when cross-INEL transits were required. Major weather-related delays in receipt operations had been postulated, but did not materialize. Those delays that did occur at the INEL because of wind or temperature extremes are discussed in Section 3.3.3, "Off-Normal Operations."

3.2.8 Cask and Railcar Maintenance and Inspection Operations. During the four-year shipping campaign, 22 round trip rail shipments were made between TMI and the INEL without a single safety incident resulting from rail cask or railcar performance. The transport distance was approximately 3,860 km (approximately 2,400 mi) each way for a total for the three railcars of about 370,560 km (about 230,400 mi) for the campaign. A major contributor to this safety record was the comprehensive inspection and maintenance programs developed for both the rail casks and railcars. This section briefly describes the requirements, responsibilities, and operations for the maintenance and inspection of the casks and cars; records keeping; and hardware and procedural improvements. A more detailed discussion of the inspection and maintenance for the rail casks and railcars is available in Reference 48.

3.2.8.1 Inspection and Maintenance Requirements. The requirements for Type B packages (the NuPac 125-B rail casks) are set forth by the NRC in 10 CFR 71, "Packaging and Transportation of Radioactive Material." The specific requirements for cask maintenance are found in Subpart G of 10 CFR 71, with guidelines in Regulatory Guide 7.9. The minimum inspection and maintenance requirements for the NuPac 125-B rail casks are found in Section 8 of the SAR for the cask[18] and are incorporated by the NRC as a condition of the package's certification.[49] That certification stipulates maintenance for the following items:

- **Fasteners**—Inspect for general overall condition and for stripped or damaged threads before each use. Replace damaged fasteners.

- **Overpacks**—Inspect for shipping damage and for stripped or damaged threads at the attachment points. Inspect plastic pipe plug on the end of each overpack for damage, and replace if necessary.

- **Trunnions**—Inspect the trunnion bearing surfaces for excessive wear, signs of galling, or distortion.

- **Seals**—Inspect the surfaces of all seals for tears, nicks, or cuts. Replace damaged seals.

Those items requiring periodic maintenance and the actions required are as follows:

- **Fasteners**—Replace fasteners (inner and outer vessel lid bolts and overpack attachment bolts) when damaged or, as a minimum, every five years.

- **Seals**—Replace seals annually or when damaged. In conjunction with seal replacement, inspect sealing surfaces and O-ring grooves for damaging burrs or scratches.

- **Rupture discs**—Replace the rupture discs for the inner and outer vessel lids annually or when damaged.

- **Inner impact limiters**—Inspect the inner vessel impact limiters annually for damage to the external skins and for axial deformations in excess of 10%. Correct skin damage before further use, and replace when permanent axial deformations in excess of 10% occur on the impact limiter.

The requirements for railcar inspection and maintenance are not as clearly defined in regulations as are those for the shipping casks. NRC regulations cover packages and not necessarily transport vehicles (the TMI-2 railcars were not addressed by NRC). The Association of American Railroads (AAR) states in its *Field Manual of the Interchange Rules* that each railroad is responsible for the condition of the cars on its lines.[50] Appendix D of 49 CFR 215 specifies the inspection and corrective actions required each time a railcar is used. However, 49 CFR does not identify frequency or type of in-service maintenance and inspection, (disassembly, inspection, and preventive maintenance requirements). Inspection and maintenance of the railcars were developed, as discussed below.

3.2.8.2 Responsibilities. Inspection and maintenance for the rail casks were performed primarily by GPU Nuclear at TMI in conjunction with the cask loading operations, and to a lesser extent, by EG&G Idaho, in conjunction with cask receipt and unloading operations. Table 3-7 is a list of cask inspection and maintenance items performed at TMI-2 and the INEL. An exploded view of the NuPac 125-B cask is shown in Figure 2-5. Reference 51 contains the program directive developed by EG&G Idaho in conjunction with GPU Nuclear for the NuPac 125-B casks. The directive identified each cask inspection and maintenance requirement and the corresponding organizational responsibilities. The directive also contained an index that accompanied each shipment and documented the inspections and maintenance performed at TMI-2 and the INEL. EG&G Idaho was responsible for providing cask spare parts for the maintenance performed at both TMI-2 and the INEL. A spare parts list maintained for the casks is found in Reference 52.

Inspection and maintenance of the railcars were performed by UP under contract to EG&G Idaho. An exploded view of the railcar is shown in Figure 2-16. Since the railcars were important for ensuring the safety of the shipments, two inspection and maintenance checklists were jointly developed by UP and EG&G Idaho. One checklist was used by UP for acceptance of the cars before release from the INEL (i.e., at CFA).[53] The second checklist provided the details for the complete disassembly, inspection, preventive maintenance, and reassembly of each railcar

Table 3-7. List of NuPac 125-B rail cask inspection and maintenance items performed at TMI-2 and the INEL.

TMI-2, GPU Nuclear	INEL, EG&G Idaho
Overpack bolts	Overpack bolts
Overpacks	Overpacks
Cask exterior	Cask exterior
Lid fasteners (bolts)	Lid fasteners (bolts)
ICV and OCV collars	Cask trunnions
ICV and OCV lids	MICARTA inserts (in skid to support lower or pivot trunnion)
Impact limiters: visual and dimensional	Non-routine items
Lid O-rings	
Vent port seal	
Test port seal	
Rupture disk	
Maintenance verification leak test	
Assembly verification leak test	
Non-routine items	

which was performed by UP at its car maintenance facility in Pocatello, Idaho.[54] Table 3-8 summarizes the inspection and maintenance actions for each railcar component and the applicable requirement. As part of the maintenance contract, UP was responsible for providing all of the materials and parts for car maintenance.

3.2.8.3 Operations. Inspection and preventive maintenance of a cask were performed in conjunction with the cask loading and unloading operations. Preventive maintenance procedures developed for the casks were more comprehensive than required by regulations. Table 3-9 shows a comparison between the requirements and the inspection and preventive maintenance procedures imposed by the TMI-2 Program. A checklist was used to record the actual in-service inspections and maintenance performed on each cask. The checklist included inspection and maintenance activities performed by both GPU Nuclear during cask loading and preparation for shipping to the INEL, and by EG&G Idaho during cask receipt, unloading, and reassembly at the INEL. Inspection and maintenance activities were performed using detailed instructions, and the results were recorded in writing. EG&G Idaho also performed a receipt inspection at CFA. A copy of the inspection instructions is provided in Reference 55.

The inspection and preventive maintenance for a TMI-2 railcar were also more comprehensive than for standard railcars. Standard railcars undergo a thorough inspection and preventive maintenance after several years of service or when defects are observed. Since the TMI-2 cars were new at the start of the shipping campaign, EG&G Idaho decided to have UP initially perform a complete inspection and preventive

Table 3-8. Railcar component, inspection/maintenance actions, and applicable requirements.

Railcar components	Inspection/maintenance actions	Applicable requirement
Coupler assembly		
– Couplers/	Check worn/distorted contour	AAR Rule 16
– Knuckles	Use correct knuckle	AAR Rule 16
	Check shank wear	AAR Rule 16
	Inspect knuckle pin and draft key	—
	Check coupler side and top clearance	AAR Rule 16
	Check height from rail and toggle clearance	—
	Check uncoupling mechanism	AAR Rule 22
	Inspect Freightmaster cushioning device and backstop casting	AAR Rule 59
Brakes	Inspect/replace defective air brake hoses	AAR Rule 5
	Check train line brackets, supports, angle cocks, and piping	Manual of Standards
	Inspect brake levers/beam, guides, rods, pins	AAR Rules 6, 9, and 10
	Perform single car air brake test	Pamphlet 5039-4
	Inspect brake shoes	AAR Rule 12
	Inspect brake connection pins/cotters	AAR Rule 9
	Inspect body brake rigging	AAR Rule 11
	Clean, oil, test, and record (stencil date)	—
Span bolster	Inspect span and body bolster, center plate for cracked/broken members	—
	Measure side bearing clearances between car, span bolster, and trucks	—
Truck assembly	Inspect truck bolsters, side frames for bad parts	AAR Rules 47 and 48
	Inspect and gauge wheels	AAR Rule 41
	Inspect roller bearing for damage	AAR Rule 36
	Inspect roller bearing adapters	AAR Rule 37
	Check springs and snubbers	—
	Apply center plate lube	—
Car body	Inspect car body side, center sills, and crossbearers for bad parts	—
	Measure and record minimum clearance between lowest point of trucks and top of rail	AAR Rule 88A12
Remarks	Inspector records, dates, and certifies all inspections and repairs	—

Table 3-9. Rail cask inspection/maintenance requirements in comparison to more thorough actions taken.

Item	Requirement	Procedures as imposed by TMI-2 Program
Assembly verification leak test (AVLT)	Perform AVLT before shipment of each loaded cask	Maintenance verification leak test (a more sensitive test) was used in lieu of the AVLT; exceeded SAR requirements
Lid O-rings	Clean and inspect O-rings at each cask loading	O-rings were replaced at each cask loading; exceeded the SAR requirements
Vent port stat-o-seal	No routine inspection required. Leak tests will verify seal integrity	The vent port stat-o-seal was replaced at each cask loading; exceeded SAR requirements
Overpacks	Visually inspect internal threads for damaged or stripped threads annually, and after each use. Inspect plastic pipe plug for damage.	This inspection was performed at each cask loading, and included inspection of the overpack exterior for damage
Internal (upper and lower) impact limiters	Inspect for skin damage or axial deformations annually	Impact limiters were visually inspected at each cask loading in conjunction with decontamination, which exceeded SAR requirements
MICARTA inserts	None	Inspected the MICARTA inserts in the trunnion guide blocks for wear semiannually
Cask exterior	None	Inspected the exterior of the cask for dents, gouges, or other obvious damage at each cask loading
Inner vessel decontamination	None	GPU Nuclear decontaminated inner lid, inner vessel, and impact limiters; reduced spread of contamination and exposure to workers
Remove residual water	None	EG&G Idaho removed residual water from each canister cavity to reduce contamination

maintenance service after each round trip. Inspections and preventive maintenance entailed a detailed tear-down inspection of each car every 7,720 km (4,800 mi). By the end of the third trip for each car, consistent operating histories were developing and the frequency of corrective maintenance was reduced. UP and EG&G Idaho determined that the detailed inspections and preventive maintenance could be changed to every third round trip, or about 23,160 km (14,400 mi), with reasonable assurance of a large degree of conservatism. On-site inspections conducted at the INEL before each return trip to TMI-2 provided an additional level of confidence that the railcar would not fail during transport. If an inspector would have observed a deficiency that could not be corrected on-site, the railcar would have been routed to the UP maintenance facility for repair; however, that situation never occurred.

3.2.8.4 Records Keeping. Maintaining complete records of all maintenance and inspection activities for certified packages is mandatory for continuing certification of the package. NRC Regulation 10 CFR 71, Subpart G, "Operating Controls and Procedures," Section 91.91(c), requires that the licensee maintain, for the life of package, sufficient quality assurance records for the cask that show evidence of quality of the components that have safety significance, and services affecting quality. As stated in Section 3.2.8.2, EG&G Idaho, with the support of GPU Nuclear, developed a NuPac 125-B maintenance plan in order to ensure compliance with NRC's maintenance requirements. EG&G Idaho maintains those records in a custodian file at the INEL. EG&G Idaho also has records of all the inspections performed by UP on the railcars. Those records are also being maintained in the cask custodian files and will be kept for the life of the railcars.

3.2.8.5 Hardware and Procedural Improvements. As a result of the comprehensive inspection and preventive maintenance program initiated on the NuPac 125-B casks and railcars, there were numerous improvements made to the operations, thus reducing the maintenance efforts. Table 3-10 identifies items that required more maintenance on the casks and railcars than anticipated and what corrective actions were taken to remedy the situations.

3.2.9 Cask Radiation Readings. The NuPac 125-B casks were designed and analyzed to meet the NRC shielding requirements for normal and hypothetical accident conditions.[18] Those requirements are approximately as follows (the casks were actually on an exclusive-use vehicle and had higher allowable dose rates for normal conditions):

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Lanyards on pins attached to the skid	Vinyl coating broke at crimp tie, allowing tie and coating to slide over cable, causing lanyard loop to open.	Replaced with uncoated stainless steel cables.
Overpacks	Difficult to install bolts because they are heavy, long, and hard to maneuver into blind holes.	Added tapered lead-in collars around each bolt hole inside overpacks.
Railcar		
Excessive brake shoe replacement	Pads on shoes cracked before wearing out. Brake shoes faulty.	Ordered new brake shoes from another manufacturer. Improved controls for releasing brakes.
Span bolster center bowl wear ring cracking	Wear ring and attachment weld cracking.	Repairing and building up welds. Forged ring with machined press fit into center bowls an alternative.
Tilt of railcar bed	Lube disks too hard and failed to compress. Motion from railcar movement caused disk to tear at center pinhole and ball up, causing bed to tilt.	Replaced by lube material melted into bowl.
Wheels	Grade U wheels had excessive treadwear.	Replaced with harder Grade C wheels and rotated direction.

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Gamma	37	84	27	33	6.3	8.0	6.2	5.6
Neutron	—	—	—	—	—	—	—	—
Total	37	84	27	33	6.3	8.0	6.2	5.6
Limits[b]	200	200	200	200	10	10	10	10

a. Dose rate without lids.

b. 10 CFR 71.47 and 49 CFR 173.441 limits (not considering an exclusive-use vehicle)

calculated in the NuPac SAR. The highest measured dose rate at contact with the cask surfaces was 12 mR/hr for cask load 14, the lowest was less than 0.1 mR/hr for several casks, and the average for all casks was about 2.1 mR/hr. The highest measured dose rate at 2 m from the cask surface was 3 mR/hr for cask load 14, the lowest was less than 0.01 mR/hr for several casks, and the average was less than 0.1 mR/hr over all casks. The lower readings are essentially the level of natural background readings at the INEL. The actual measurements are well below the calculated dose rates, which in turn are significantly below the maximum allowable of 10 CFR 71.47(b) and (c) and 49 CFR 173.441. The actual low dose rates are a verification of the conservative assumptions used in designing the cask.

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- An escalation of rates was incurred near the end of the shipping campaign. The escalation of rates required considerable negotiation before reaching mutual consensus as to an agreeable percentage increase.

- Considerable correspondence on expedited service costs for multiple cask shipments occurred, which eventually resulted in agreements that Conrail would charge $17,500 for the first cask but only $5,000 for each additional cask on a train. UP agreed that $29,500 was sufficient regardless of the number of casks per train.

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May 10, 1993

ERRATA SHEET

Report number:	DOE/ID-10400
Report title:	Historical Summary of the Three-Mile Island Unit 2 Core Debris Transportation Campaign
Prepared by:	EG&G Idaho, Inc. (Idaho National Engineering Laboratory)
Date published:	March 1993
Distribution category:	UC-523, S-523
Instructions:	The text on pages 3-23 through 3-26 has been revised to include two lines of text that were inadvertently omitted. Please replace pages 3-23 through 3-26 of your copy with the attached pages.

maintenance service after each round trip. Inspections and preventive maintenance entailed a detailed tear-down inspection of each car every 7,720 km (4,800 mi). By the end of the third trip for each car, consistent operating histories were developing and the frequency of corrective maintenance was reduced. UP and EG&G Idaho determined that the detailed inspections and preventive maintenance could be changed to every third round trip, or about 23,160 km (14,400 mi), with reasonable assurance of a large degree of conservatism. On-site inspections conducted at the INEL before each return trip to TMI-2 provided an additional level of confidence that the railcar would not fail during transport. If an inspector would have observed a deficiency that could not be corrected on-site, the railcar would have been routed to the UP maintenance facility for repair; however, that situation never occurred.

3.2.8.4 Records Keeping. Maintaining complete records of all maintenance and inspection activities for certified packages is mandatory for continuing certification of the package. NRC Regulation 10 CFR 71, Subpart G, "Operating Controls and Procedures," Section 91.91(c), requires that the licensee maintain, for the life of package, sufficient quality assurance records for the cask that show evidence of quality of the components that have safety significance, and services affecting quality. As stated in Section 3.2.8.2, EG&G Idaho, with the support of GPU Nuclear, developed a NuPac 125-B maintenance plan in order to ensure compliance with NRC's maintenance requirements. EG&G Idaho maintains those records in a custodian file at the INEL. EG&G Idaho also has records of all the inspections performed by UP on the railcars. Those records are also being maintained in the cask custodian files and will be kept for the life of the railcars.

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Table 3-12. Rail shipping costs charged by carriers.

	Costs for rail shipment number ($)									
Carrier	1 and 4	2 and 3	5, 6, 12	7, 8, 9, 10, 11	13	14	15 and 16	17	18, 19, 20, 21	22
Conrail	12,375[a]	12,375[a]	12,375[a]	12,375[a]	12,375[a]	11,687[a]	11,687[a]	11,687[a]	12,517[a]	12,517[a]
	3,992[b]	12,375[a]	5,580[b]	12,375[a]	12,375[a]	11,687[a]	11,687[a]	11,687[a]	12,517[a]	12,517[a]
	17,500[c]	3,992[b]	17,500[c]	5,580[b]	12,375[a]	11,687[a]	11,687[a]	11,687[a]	12,517[a]	12,517[a]
	—	3,991[b]	—	5,580[b]	4,785[b]	4,785[b]	4,785[b]	5,125[b]	5,125[b]	5,125[b]
	—	17,500[c]	—	17,500[c]	4,785[b]	4,785[b]	4,785[b]	5,125[b]	5,125[b]	—
	—	5,000[c]	—	5,000[c]	4,785[b]	4,785[b]	4,785[b]	5,125[b]	5,125[b]	—
	—	—	—	—	17,500[c]	17,500[c]	17,500[c]	17,500[c]	18,743[c]	18,743[c]
	—	—	—	—	5,000[c]	5,000[c]	5,000[c]	5,000[c]	5,355[c]	5,355[c]
	—	—	—	—	5,000[c]	5,000[c]	5,000[c]	5,000[c]	5,355[c]	5,355[c]
UP	19,560[a]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	20,860[a]	20,860[a]
	29,500[c]	19,560[a]	7,095[b]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	20,860[a]	20,860[a]
	7,095[b]	7,095[b]	29,500[c]	7,095[b]	19,560[a]	19,560[a]	19,560[a]	19,560[a]	20,860[a]	20,860[a]
	—	7,095[b]	—	7,095[b]	7,095[b]	7,095[b]	7,095[b]	7,562[b]	7,562[b]	7,562[b]
	—	29,500[c]	—	29,500[c]	7,095[b]	7,095[b]	7,095[b]	7,562[b]	7,562[b]	—
	—	—	—	—	7,095[b]	7,095[b]	7,095[b]	7,562[b]	7,562[b]	—
	—	—	—	—	29,500[c]	29,500[c]	29,500[c]	29,500[c]	31,447[c]	31,447[c]
	—	—	—	—	—	3,625[d]	—	—	—	—
	—	—	—	—	—	3,625[d]	—	—	—	—
	—	—	—	—	—	3,625[d]	—	—	—	—

a. Loaded cask shipment.

b. Empty cask shipment.

c. Expedited service charge.

d. Expedited empty cask shipment.

Table 3-13. Costs at the end of the campaign for typical three-cask shipments.

	Cask 1 ($)	Cask 2 ($)	Cask 3 ($)
Conrail			
Loaded	12,517	12,517	12,517
Expedited service	18,473	5,355	5,355
Empty return	5,125	5,125	5,125
UP			
Loaded	20,860	20,860	20,860
Expedited service	31,447	—	—
Empty return	7,562	7,562	7,562
Total	96,254	51,419	51,419
Loaded one-way to the INEL			
Total three casks	161,031		
Cost per cask (average)	53,677		
Cost per mile per cask (2,400-mi route basis)	22.36		
Unloaded one-way to TMI			
Total three casks	38,061		
Cost per cask	12,687		
Cost per mile per cask (2,400-mi route basis)	5.29		
Round trip			
Total three casks	199,092		
Cost per cask (average)	66,364		
Cost per mile per cask (2,400-mi route basis)	13.82		

- Gas generation monitoring performed at TMI-2
- Minor modification to the plug used to seal canisters
- Allow use of cadmium plated bolts in the cask's lids and overpacks
- Corrected inconsistencies in the cask's SAR drawing
- Proposed change to the size of fuel particles allowed in filter canisters
- Reconsolidation of the SAR.

3.3 Receipt and Storage Operations

Dates for shipment from TMI-2, receipt at the INEL, release for return to TMI-2, and arrival at TMI-2 for each rail shipment are listed in Table 3-6. The number of days each cask was at TMI-2, in transit between TMI-2 and the INEL, and at the INEL are also shown. Appendix J lists detailed information about each cask load, including (a) weight of core debris, (b) durations in transit and at each site, (c) radiation and contamination levels, and (d) general comments.

3.3.1 Normal Operations. As described in Section 2.7, a sizable effort was undertaken to prepare the INEL facilities to receive the casks and to store the canisters of TMI-2 core debris. The planning, dry runs, readiness reviews, and cold (nonradioactive) tests helped to ensure that receipt and storage operations for the first loaded NuPac 125-B cask were accomplished as expected and with minimal delays. Because the equipment and operating procedures were ready and the personnel had been trained, the handling and unloading of the first cask was successful and set the precedent for subsequent casks. Table 2-3 identifies the DOPs for handling the casks at the INEL.

During the campaign, the cask and canister handling operations at both TMI-2 and the INEL were closely monitored and coordinated between personnel at the INEL, TIO, and GPU Nuclear. Information significant to transport or canister handling at the INEL was immediately provided to improve INEL operations and to eliminate surprises wherever possible. Similarly, the INEL provided letters to GPU Nuclear that summarized all observations, inspections, and corrective actions identified and performed at the INEL for each shipment (see Reference 56 for an example).

3.3.1.1 Cask Receipt/Transfer Operations at CFA. Personnel involved in the cask handling operations at CFA were properly trained and briefed before performing a cask transfer operation. All operations were performed in compliance with applicable safety requirements at the INEL. Since the operations at CFA were performed outside, weather conditions were an additional safety consideration in the operations. No movement of a cask was allowed if the ambient temperature was below -18°C (0°F), or if the winds were higher than 32 km/hr (20 mi/hr). These restrictions ensured the safety of the operators and equipment. Every step in the operations was performed in accordance with instructions in the DOPs. Cask handling operations included oversight by a project supervisor and a job supervisor.

3.3.1.1.1 Preparation for Transport to TAN— Once UP delivered a TMI-2 cask shipment to the Scoville Siding at the INEL, security personnel met the train and provided security until an INEL train crew and locomotive retrieved and delivered the shipment to CFA. Movements to CFA usually occurred the morning of the first working day after a shipment arrived. Every movement was preceded by a briefing for personnel of the plans for the activities that day. At CFA, the environmental covers were radiologically surveyed by a health physics technician and then removed by an operations crew using the spreader bar and mobile crane. Radiological surveys of the cask and railcar surfaces were completed, and the cask was inspected for shipping damage by a quality inspector. The inspection checklist included recording any identified deficiencies. The work platforms were then installed on the transportation skid on each side of the cask. The railcar and cask were positioned under the gantry crane for overpack removal. The sequence of activities required to transfer a cask between a railcar and the transporter is shown in Figure 2-28.

The railcar positioning device (see Figure 3-3) was used during the first few shipments to remove the overpacks. Two mobile cranes were required. The overpack lift fixture assembly (see Figure 3-3) was attached to a mobile crane and to an overpack. The weight of the overpack was lifted, freeing up the overpack bolts for removal. A second crane was used to hold the railcar positioning device in place between the railcar and locomotive. A hydraulic ram was slowly extended or retracted, depending on which overpack was being removed. From the force of the ram, the overpack slowly slid off of the cask. Once the ram was totally extended or retracted, it was reset and the operation was repeated until the overpack was clear of the cask. The overpack was placed in a laydown area, and the operation was repeated on the second overpack. The ends of the-cask were surveyed after each overpack was removed. The railcar and the cask, without the overpacks, was then positioned under the gantry crane and the transporter skid with cask was prepared for transfer to the transporter.

However, the railcar positioning device proved to be very time-consuming and difficult to handle and operate. After the first few shipments, the gantry crane was used in place of the railcar positioning device. The gantry crane proved more versatile, eliminated the need for a second crane, and centralized most of the CFA operations in one area. Once the environmental cover had been removed and the work platforms had been installed, a railcar and cask were positioned under the gantry crane and the railcar brakes were locked. The overpack lift fixture assembly, hooked to the bridge of the gantry crane, was attached to the overpack and adjusted. After the overpack was lifted slightly, the bolts were removed and the gantry crane was rolled to slide the overpack away from the end of the cask. An overpack was placed on the storage stand or on the end of the railcar, depending on which overpack was removed. The operation was repeated for the second overpack. The ends of the cask were surveyed after each overpack was removed. Using the gantry crane to remove the overpacks reduced the time for that operation from one full day for both to less than 30 minutes per overpack.

Once the railcar and cask were in position with the overpacks removed and the contamination surveys complete, the cask horizontal lift fixture was attached to the gantry crane and the lifting lugs on the transport skid (see Figure 3-4). The tiedown pins between the railcar and transport skid were removed (see Figure 3-5). The cask and transport skid were lifted vertically and moved to one side. Chocks were removed from the wheels of the railcar, the brakes were released, and the railcar was moved from under the crane using the locomotive. The tractor trailer was moved into position under the crane and the wheels were blocked. The cask and transport skid were moved into position over the transporter and lowered onto the trailer, and the tiedown pins were installed (see Figure 3-6). The horizontal lift fixture was disconnected from the transport skid, raised clear of the cask, and moved to one side. The work platforms were then removed. Health physics technicians performed a final survey of the cask and trailer and recorded the results on Form ID F-5480.1A, "U.S. DOE Off-Site Radioactive Material Shipment Record" (same form used for on-site shipment). A safety engineer visually inspected the loaded truck transporter to verify that the cask transport skid was securely fastened and that all on-site radioactive shipment prerequisites had been met. Each end of the cask was covered with a tarp to prevent buildup of dirt and ice during transport. Wheel blocks were removed, the vehicle was placarded, and the "Oversized Load" banner was placed in front of the tractor and on the rear of the trailer. The driver performed a final inspection of the tractor, trailer, tiedowns, and cask. The security escorts performed a security inspection of the tractor, trailer, and cask so that the vehicle could

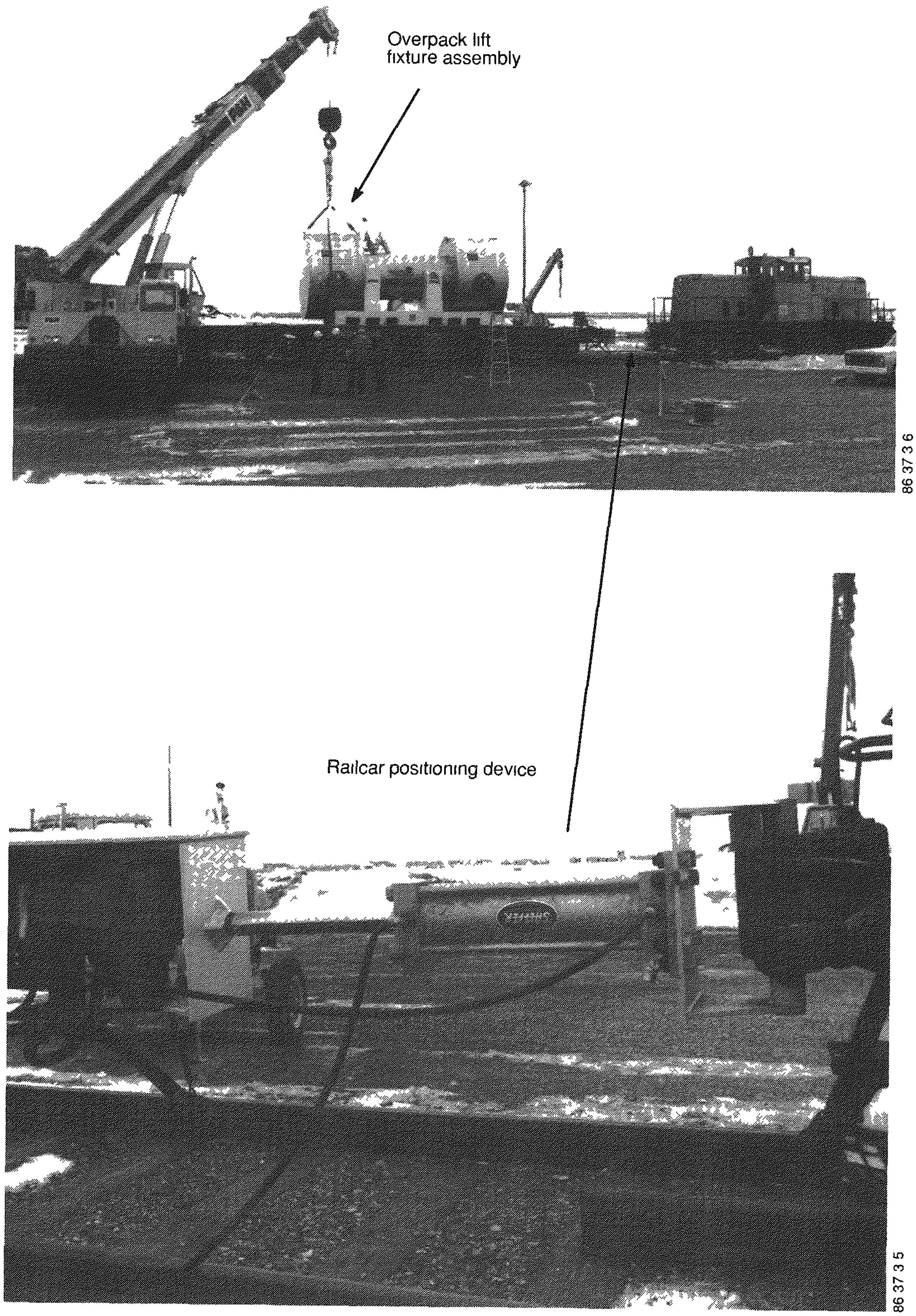
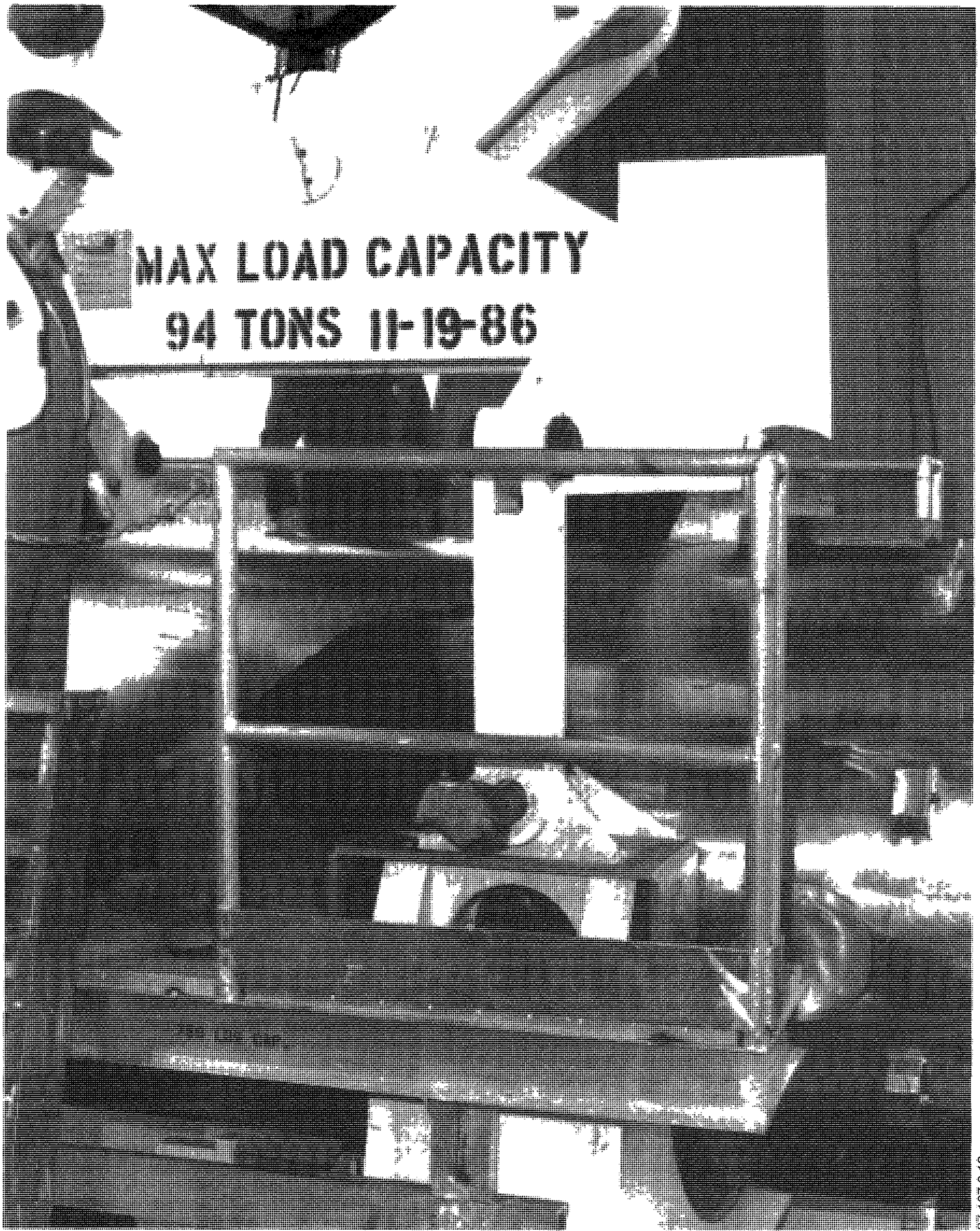


Figure 3-3. Railcar positioning device.



87 167 6 12

Figure 3-4. Lifting lugs on the transport skid

87-167-8-5

Figure 3-5. Tiedown pins between a railcar and transport skid were pulled.

87 167 5 3

Figure 3-6. A cask and transport skid were positioned over the transporter and lowered onto the transporter, and the tiedown pins were installed enter the TAN facility without being stopped and inspected at the entrance gate. The cask was ready for transport to TAN once the final notifications and briefings were completed.

Notifications were made to TAN Hot Shop Operations in preparation to receive the shipment. Notifications were also made to key personnel required to be aware that a movement was underway in the event of an emergency. The project supervisor made the following notifications: EG&G Idaho Security organization; DOE-ID TMI Programs and the Operational Safety Department; TAN Hot Shop Operations; CFA Fire Department; and Radiological and Environmental Sciences Laboratory. The security escorts notified the INEL Warning Communication Center before a movement and upon arrival at the destination.

The following documents accompanied each shipment:

- "Checklist for Shipping TMI-2 Core Debris to INEL and Return of Empty Cask," Reference 51, with Tables 1 through 4 completed

- Form ID F-5480.1A, "U.S. DOE Off-Site Radioactive Material Shipment Record"

- DOE/NRC Form 741, "Nuclear Materials Transaction Report"

- Isotopic information sheet

- Canister loading diagram

- Quality receiving inspection report from "Detailed Operating Procedure for Receipt of NuPac 125-B Cask and Transfer from Railcar to Truck Transfer," Planning No. 12355, Receiving Inspection Instructions

- NuPac 125-B Cask Maintenance Records Index.

3.3.1.2 Transport Between CFA and TAN. The requirements and controls for transport across the INEL were contained in the *Transport Plan for Movement of TMI Core Debris Across INEL.*[40] DOPs (see Table 2-3), which delineated the detailed instructions to implement the controls, were required because the cask was moved across the INEL using a configuration that was different from that approved by NRC in cask licensing (e.g., there were no overpacks used while in transport across the INEL). The following is a list of the special controls:

- The driver and an alternate were required to be properly trained and qualified to make a radioactive material shipment.

- The truck transporter could not be moved during adverse weather conditions, that is, high winds, blowing or drifting snow, or heavy rains. If road conditions were questionable, the project supervisor was to verify that conditions on the route were acceptable before moving the load.

- Truck transporter speed was not to exceed 10 mph through CFA and TAN areas, 15 mph on the open highway, and 5 mph across the Lincoln Boulevard bridges.

- The truck transporter was to be moved during daylight hours only (1/2 hour before sunrise to 1/2 hour after sunset).

- The truck transporter could not be moved between CFA and the Naval Reactor Facility during hours of peak traffic for weekday shift changes, that is, from 7:30 to 8:30 a.m. or 4:00 to 5:00 p.m.

- The truck transporter was to be driven over the center of the Lincoln Boulevard bridges.

- Escort vehicles were to be in front and rear of the truck transporter with flashing lights and had to have radio contact with the drivers. The escorts provided warning to oncoming traffic of the truck transporter, ensured that traffic passed the truck transporter safely, and were available to provide on-the-scene emergency response (although none was ever needed).

Before an actual movement began, the driver and alternate, and escorts were briefed on the transport operation. The briefing covered the route, special controls, and emergency response procedures. The escorts and drivers signed the briefing log in the DOP. After the truck transporter was released, the alternate driver used the DOP to inform the driver of speed restrictions and special requirements along the route. The alternate signed off after each step was completed. The distance between CFA and TAN was approximately 42 km (26 mi) and took over two hours to travel. During each of the shipments across the INEL, the project supervisor or an alternate accompanied the shipment in a separate vehicle to provide assistance if needed.

3.3.1.3 Core Receipt and Storage Operations at TAN. Two major tasks were performed at TAN: cask unloading and preparation of canisters for storage.

3.3.1.3.1 Cask Receipt, Unloading, and Reassembly—Upon arrival at TAN, the truck transporter was backed into the HECF, and the documentation accompanying the shipment was transferred to TAN Hot Shop Operations personnel. The shift manager verified that the shipping papers were complete and removed the information on how the cask was loaded with canisters. The nuclear material custodian was notified of the cask's arrival and was given the documents for nuclear material accountability. The cask, tractor, and trailer were surveyed for external radiation dose rates and contamination. Dirt, snow, and ice were removed from the cask, tractor, or trailer when necessary. Health physics personnel obtained the shipping papers and verified preshipment radiological information. Quality assurance personnel inspected the cask for physical damage and verified that the Receiving Inspection Report was completed. Mechanics removed the four trunnion blocks from the transport skid and the shear plates from under the cask.

While the transporter and cask were inspected and prepared in the HECF for the next step, technicians were also preparing the Hot Shop. Plastic sheeting was laid on the floor to control contamination, including around the storage pool vestibule area. The removable section of the cask work platform was removed and placed in a storage area, and the cask handling tools and equipment were retrieved from storage. A hose vented to the outside of the HECF was attached to the exhaust pipe of the tractor to prevent damage to the filters in the Hot Shop H&V system from diesel exhaust.

After the Hot Shop doors were opened, the truck transporter was backed into place. The cask vertical lift fixture, attached to the 100-ton overhead crane, was centered over the lifting trunnions near the lid end of the cask. The lift fixture was slowly maneuvered under the lifting trunnions, and the fixture was raised until the trunnion was seated inside the lift fixture grips. The lid end of the cask was then slowly rotated to vertical (see Figure 3-7). The crane bridge was moved towards the bottom end of the cask as the lid end was being lifted to ensure that the lift fixture remained vertical during the uprighting. Once the cask was in the vertical position, it was lifted up and out of the rear support of the transport skid, moved over the side of the trailer, and lowered to approximately 6 in. above the shop floor. The Hot Shop doors were opened, the unloaded truck transporter was removed from the Hot Shop into the HECF, and the Hot Shop doors were closed. The crane slowly moved the cask to the work platform, centered it inside the opening, and lowered it to the floor. The lift fixture was detached from the lifting trunnions, and the fixture was returned to its storage stand before being disconnected from the crane.

Plastic sheeting was installed on the exterior vertical surfaces and around the base of the cask before the removable section of the work platform was retrieved from storage and installed around the cask. The platform provided access for the Hot Shop technicians to the top of the shipping cask.

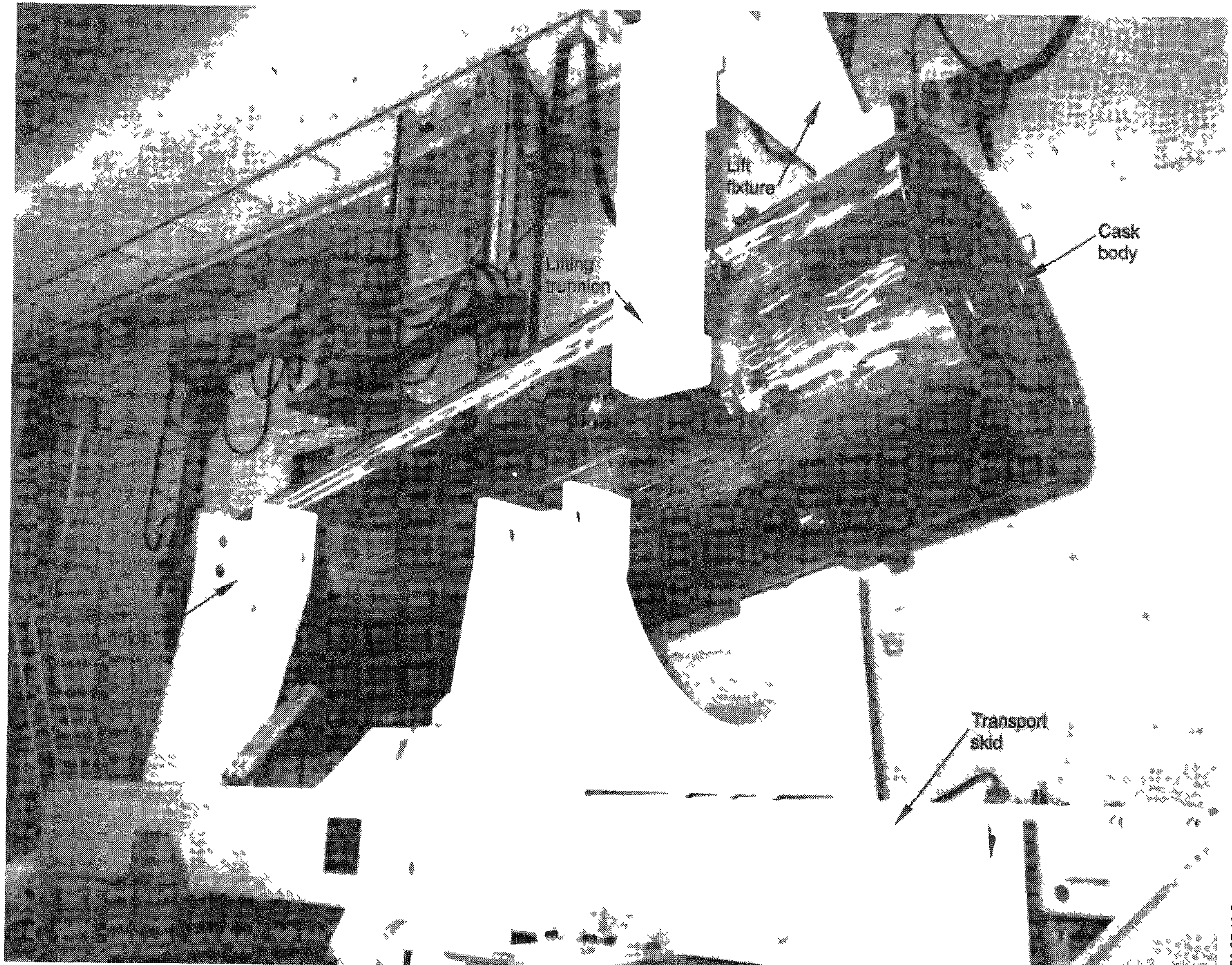


Figure 3-7. The lift fixture was slowly maneuvered under the lifting trunnions, and the fixture was raised until the trunnion was seated inside the lift fixture grips

The cask vent port tool was installed into the vent port of the outer cask lid. Gas inside the OCV was vented through an inline-filter holder with a 47-mm (0.28-in.) membrane filter into the HEPA filter of the Hot Shop H&V system. The membrane filter was removed from the filter holder, bagged, taken from the Hot Shop, and counted for contamination. If a filter would have had more than 10 nCi (2.22 x 10^4 dpm) of Cs-137 or any other radionuclide, a leak of both the lid of the ICV and a canister would have been assumed. Contamination levels on the filter were always below the 10 nCi level and a leak was never detected in a cask, ICV, or canister. While the filter was being counted, the 32 lid bolts on the OCV were untorqued, removed, inspected, and placed in a storage rack. Upon determination that the filter was clean, the cask cavity was vented through the vacuum system into the HEPA filter system and out the Hot Shop's H&V system. The outer cask lid was removed from the cask, checked for contamination, and placed on a support stand. A plastic protector was placed over the cask body's sealing surface for the outer cask lid in preparation for removal of the ICV lid.

As with the outer cask lid, the vent port tool was installed into the vent port of the ICV lid. Gas was vented through a filter into the Hot Shop HEPA filter in the H&V system to check for leaks, but none were ever detected. The 24 ICV lid bolts were untorqued, removed, inspected, and placed in a storage rack. Upon determination that no leak had occurred, the ICV cavity was vented through the vacuum system into the HEPA filter system and out the Hot Shop H&V system. The ICV lid was removed, checked for contamination, and placed on a support stand. A protector was placed over the sealing surface on the ICV flange.

An eye bolt lifting adapter was screwed into each of the seven ICV canister port shield plugs and all personnel left the Hot Shop in preparation for remote canister removal operations. The shield plug hook adapter, attached to the O-man shoulder, was maneuvered into the eye of the shield plug lifting adapter, and a plug was removed from the ICV canister port, placed on the Hot Shop floor, and covered with plastic. This operation was repeated until all seven shield plugs were removed. Using the work platform video camera system, a Hansen™ plug was verified as installed on each nozzle on the upper head of the seven canisters. Using the overhead crane, the canister lifting grapple was moved above a canister, lowered into place, and locked into the canister lifting socket on the lid of the canister. An instrument light indicator in the gallery area, where the technicians were operating the equipment, provided verification that the canister grapple was locked in place. While lifting a canister out of an ICV canister cavity, operations technicians were able to verify that a canister was not binding by monitoring a digital readout of the weight of the canister.

A canister was slowly lifted, smeared for removable external surface contamination using a remote arm, moved over the edge of the work platform, and lowered to approximately 1 m (3 ft) above the Hot Shop floor. The canister was moved to the vestibule of the pool and lifted up and over the side of the vestibule wall. The overhead crane positioned a canister above a storage module opening and, using the underwater camera system for further position adjustment, slowly lowered the canister into the module. The grapple could not be released until all of the weight was off the grapple and a yellow indicator light was lit on the TMI-2 canister grapple control remote unit located in the operating gallery. The grapple was disconnected from the canister, and the canister number, module number, and module position were recorded. Figure 3-8 shows steps in the unloading and storage of a canister.

The steps in the cask unloading process were repeated six more times, removing all seven canisters from a cask. Once a module was filled, the remaining canister(s) was placed in a second storage module also located on the underwater cart.

Technicians and other workers were allowed to re-enter the Hot Shop after a health physics survey of the area. Free-standing water, if any, in the bottoms of the ICV canister ports, was removed initially by removing the lower impact limiter and

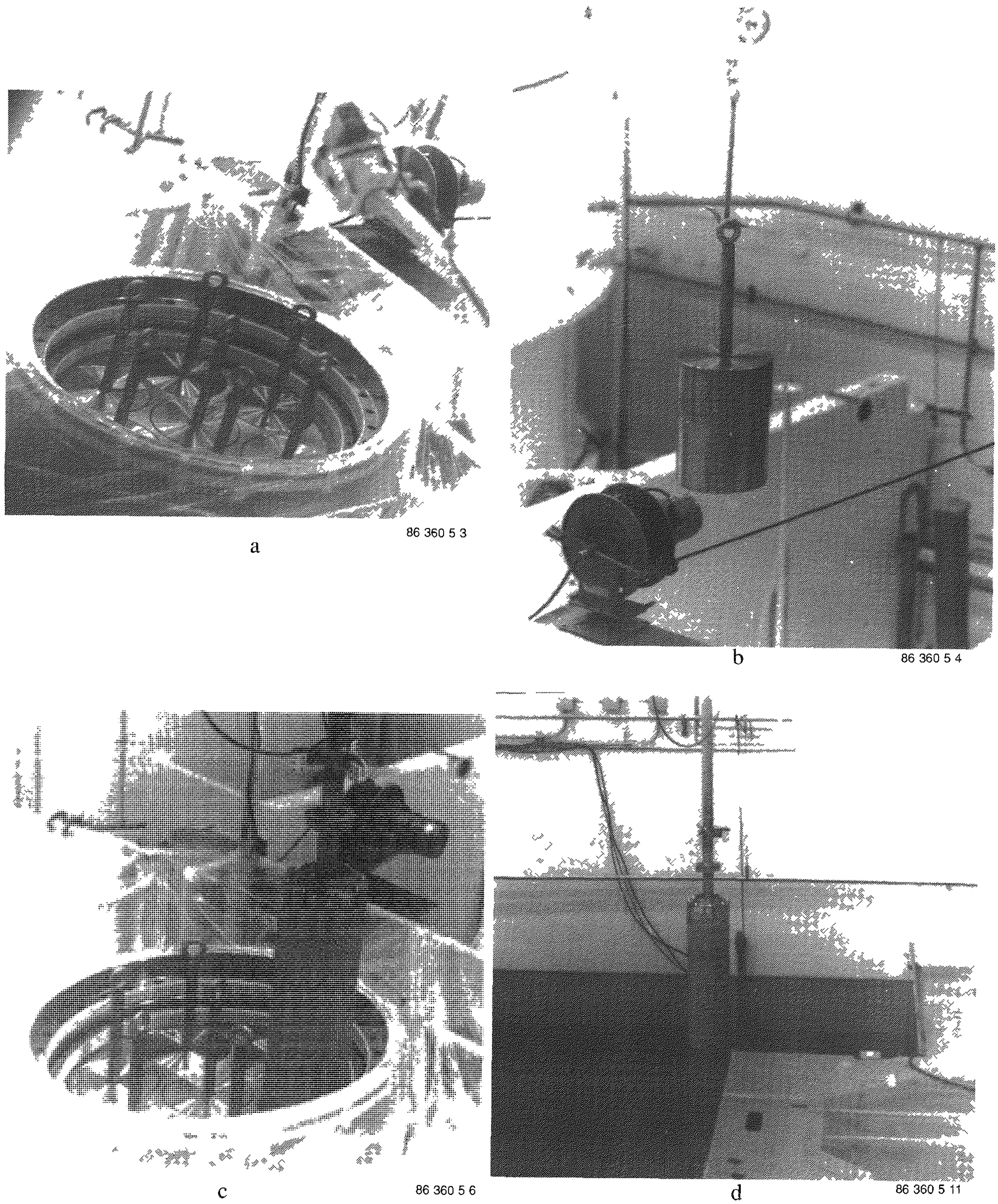


Figure 3-8. Unloading and storage of a canister

pumping out the water. After modifying the lower impact limiter design, water was removed by attaching the vacuum system to a tube through the center of the impact limiters. The amount of water and the contamination level in the water were recorded for each cavity. The interior surface of each cavity was smeared for removable surface contamination and decontaminated, if necessary, to less than 220,000 dpm, the upper limit for an empty cask-contained shipment.The empty cask was then reassembled. Each of the seven ICV shield plugs was inspected, repaired, if necessary, and reinserted into an ICV cavity. The protective cover over the ICV lid sealing surface was removed and the surfaces were cleaned. The ICV lid seals were inspected and lightly lubricated with silicone grease. The ICV lid was lowered into the ICV guided by two ICV lid index pins. The ICV bolts were retrieved, inspected, lubricated, inserted, and torqued following a star pattern using a three-step process to the final torque. The ICV vent port plug was reinstalled. A seal leakage rate test was not required since the cask was empty. The same process was followed for reassembling the outer cask lid and then the cask was prepared for reloading onto the trailer. The plastic sheets were removed from the outside of the cask, and the removable portion of the work platform was disconnected and placed in storage. The cask lifting fixture was attached to the 100-ton crane and the lifting trunnions on the cask. The pivot, or lower trunnions were lubricated. The tractor trailer was backed into the Hot Shop, and the cask was lifted and placed into the rear pivot legs of the transport skid. The lid end of the cask was lowered slowly to horizontal until the tiedown trunnions of the cask were seated in the skid. The shear plate and ratchet binders were installed between the cask body and skid. The cask lift fixture was removed from the cask and placed in storage.

Health physics personnel surveyed the trailer and cask and decontaminated them as necessary. The tractor trailer with empty cask was removed from the Hot Shop into the HECF. The trunnion caps were reassembled to hold the cask in the skid. Finally, the cask, trailer, and tractor were resurveyed and inspected. Each end of the cask was covered; shipping papers were signed-off; notifications were made; escorts and drivers were briefed; and the cask was released for return to CFA.

Prior to reassembling the two DOE-owned casks after the last TMI-2 shipment, the canister cavities in each ICV were decontaminated using a tool specially designed and fabricated for that operation. The tool was unique in that water was not used in the decontamination process. Typically, large quantities of water were required to decontaminate equipment; however, the TAN Hot Shop did not have storage capacity for the contaminated water. The tool consisted of a long handle with a dust mop/paddle assembly at the bottom. As the tool was lowered to the bottom of each cavity, the tool was rotated allowing the mop covers to collect loose surface contamination. The operation was performed twice for each cavity, and the mop covers were replaced between each operation. The tool was very effective in removing most of the loose contamination in the cavities. The tool was easy to handle and required less than one-third of the time for decontaminating the canister cavities than would have been required using conventional water-based methods.

3.3.1.3.2 Canister Water-Filling and Storage—Preparing the canisters for long-term storage required that (a) each canister be filled with water; (b) each canister be locked into a storage module; (c) each module be transferred into the storage pool and placed in a designated location; and (d) a vent tube be installed on each canister for continuous venting. The following is a more detailed discussion of these operations.

For safety reasons during transport, each canister was dewatered before leaving TMI-2 for transport to the INEL. EG&G Idaho evaluated leaving the canisters in a dewatered and unvented condition while stored in the Hot Shop pool. However, there was a possibility of water inleakage past a seal, allowing canisters to fill up with water, cover the upper bed of the recombiner catalyst, and cause a pressure buildup from radiolytic gas generation. To eliminate this possibility, the canisters were filled with water and venting tubes were attached to the canister heads, which allowed continuous venting.

After a canister was placed into a module in the vestibule of the Hot Shop pool, the canister was filled with demineralized water using the filling and dewatering system mobile cart and special underwater tools, designed by B&W and EG&G Idaho. Figure 3-9 shows technicians working on a canister in the vestibule pool area of the Hot Shop. The gas was vented through the cart to the HEPA filters in the H&V system. Once a canister was filled, the two lines were disconnected and a relief valve assembly was installed on the 3/8-in. Hansen quick-connect coupler.

Once the seven canisters from a cask were filled with water, the mobile cart was prepared for storage by draining the catch tank into a hot waste tank and purging the offgas system with argon gas to displace any potentially combustible gases that may have been collected from the canisters. All water-filling operations were performed with technicians fully clothed with anti-contamination clothing and full-face respirators.

Each water-filled canister was locked into a module. The transfer cart transferred a module from the vestibule into the main pool. The module lifting fixture, attached to both a module and the 15-ton bridge crane, was used to transfer a module from the cart to the designated storage location on the pool floor. An empty module was retrieved from storage in the pool, loaded onto the cart, and latched into place. The cart was moved back into the vestibule area in preparation for the next shipment of canisters.

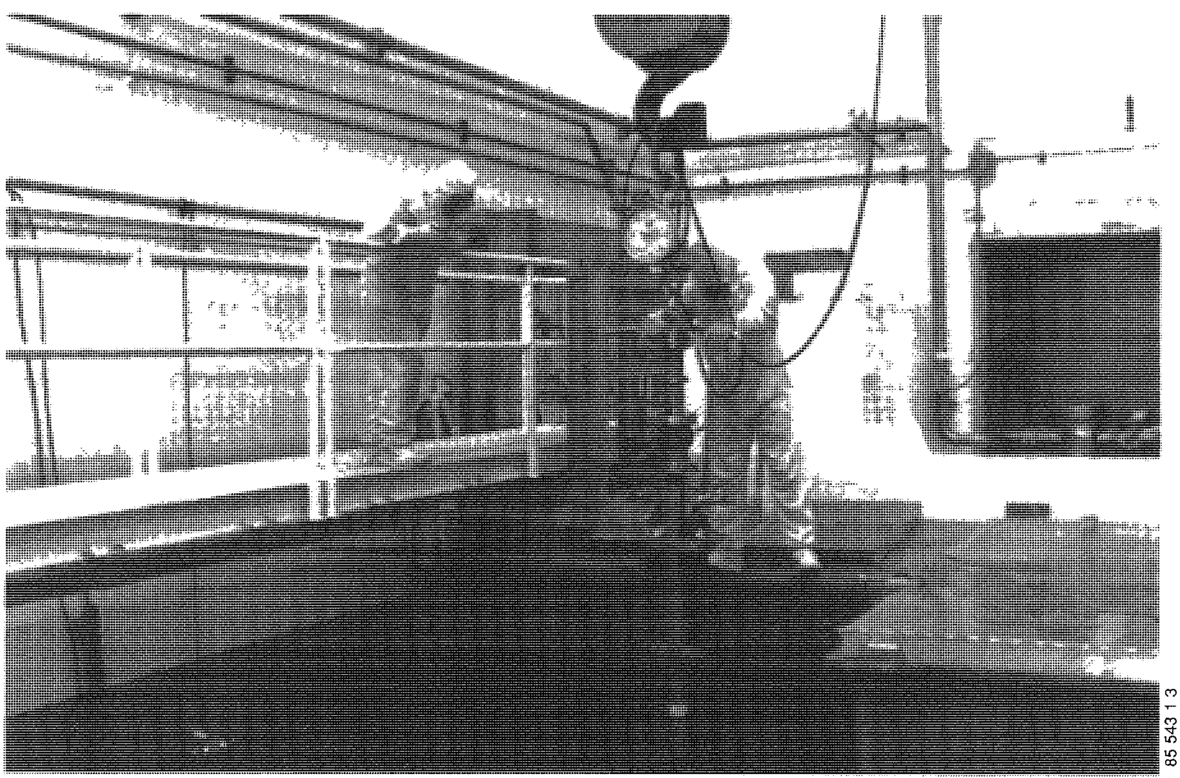


Figure 3-9. Technicians working on a canister in the vestibule pool area of the Hot Shop.

After a module was placed into position in the pool, the canisters were prepared for storage. A vent line assembly was attached to the 1/4-in. coupling on each canister. The relief valve assembly on the 3/8-in. coupling was removed and replaced with a protective cap. The vent line assembly was then filled with demineralized water to provide visible evidence that a canister was full of water. A vent provided continuous release of radiolyte gases, thus preventing gas buildup in a canister.

3.3.1.4 Preparation of Empty Casks for Transport to TMI-2. Each empty cask arriving at CFA from TAN was surveyed by a health physics technician to verify that external radiation and surface contamination levels had not changed during transit. The work platforms were installed over the lifting lugs of the transport skid, and the trailer was parked under the gantry crane and the wheels were blocked. The cask horizontal lift fixture was attached to the transport skid lifting lugs; the tiedown pins were removed; and the empty cask and skid were raised off the trailer and moved to one side. The wheel blocks were removed and the transporter was moved away from the cask handling area.

The railcar was positioned under the gantry crane, and the empty cask and transport skid were moved over the railcar and lowered into the tiedown brackets. The tiedown pins were inserted and locked in place. The overpacks were replaced at each end of the cask and the bolts were inspected and lubricated before installation. The bolts were torqued using a three-step process following a star pattern. Each bolt was tightened first to 80 ft-lb, then to 160 ft-lb, and finally to 225–270 ft-lb of torque.

A safety engineer inspected each loaded railcar to verify that the transport skid was securely fastened and that the overpacks were properly installed. Health physics technicians performed a radiation survey of the cask and recorded the results on Form F5480.1A, "U.S. DOE Off-Site Radioactive Material Shipment Record."

The work platforms were removed, and the environmental cover was replaced over the cask and fastened to the tiedown bar on the railcar deck. Responsibility for the cask was then turned over to EG&G Idaho Traffic Management for the return trip to TMI-2. Traffic Management notified UP that the railcar and cask were ready for pickup. An inspector from UP verified that the railcar was in good condition for transport before the railcar was released at CFA. The UP inspector made minor repairs, such as changeout of damaged brake shoes, if required. The railcar was normally transported on Saturday to the Scoville Siding for pickup by UP.

UP picked up the railcars and delivered them to TMI-2 either directly or via the Pocatello shop for maintenance (as discussed in Section 3.2.8.2).

The empty casks were returned to TMI-2 using regular train service. EG&G Idaho Traffic Management notified GPU Nuclear when the cask shipments were leaving the INEL and tracked the casks and railcars back to TMI-2 using each railroad's operations center. Typically, between one to two weeks were required for empty casks to return to TMI-2.

3.3.2 Improvements to INEL Operations. During the four years of receipt and storage operations for the TMI-2 core debris at the INEL, there were numerous improvements made to various aspects of the operations. Those changes resulted in cost savings of well over a million dollars. This section describes some of the types of changes that were implemented and that should be considered in future similar operations.

3.3.2.1 CFA Operations. The three major improvements in handling the casks at CFA that resulted in significant costs and schedule savings were removing the overpacks using the gantry crane; allowing on-the-spot temporary changes to be made to procedures that did not affect safety or quality of the operations; and handling two casks in one shift.

As previously discussed, using a railcar positioning device was very awkward, time consuming, and required extra equipment. Two mobile cranes were required to remove an overpack, one to lift the overpacks and the second to hold the railcar positioning device in place. The process comprised setting up the device, extending or retracting the ramp, blocking the railcar, moving the locomotive, and repeating these steps several times until the overpack was freed from the end of a cask. This operation required an entire eight-hour shift using seven people and two cranes. Using the gantry crane eliminated both the cranes and railcar positioning device. The time required to remove both overpacks was reduced to less than one hour, which significantly reduced the costs for the CFA cask handling operations.

Use of on-the-spot temporary changes to operating procedures, for changes not affecting safety or quality, better utilized personnel and equipment. Normally, deviations to procedures required a work stoppage while a Document Revision Request (Form EGG-1844) was prepared and approved. This either shut down the operations for that day, requiring rescheduling personnel and equipment for a different day, or resulted in personnel standing around waiting for approval to continue with the slightly revised operations.

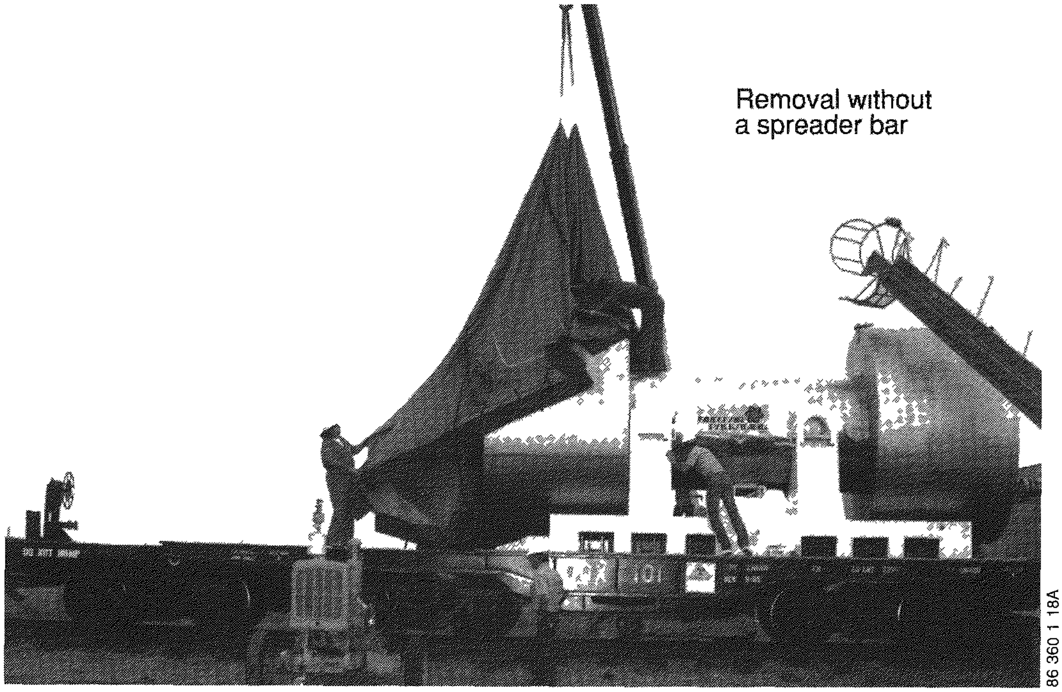
Handling two casks in one shift also resulted in better utilization of personnel and equipment. The same amount of time and effort was required to brief personnel of a day's activities and retrieve and store equipment for handling two casks in a single shift as was required for the same activities for a single cask. Handling a single cask required approximately one shift to perform the CFA operations and transport the cask to TAN. A morning was spent preparing a cask for shipment to TAN, and an afternoon was spent enroute and transferring paperwork to TAN Operations. Return of an empty cask to CFA and preparation for release to TMI-2 also required the same operations, but in reverse order.

Since these operations were the reverse of each other, time was saved when two casks were handled in one shift. In the morning, an empty cask travelled the return trip from TAN to CFA, while a loaded cask at CFA was prepared for transport to TAN by removing the overpacks using the gantry crane and then moving the railcar with the loaded cask from under the crane. After the empty railcar was placed under the crane, the empty cask was transferred from the trailer to the empty railcar. With another movement of railcars, the loaded cask was transferred from the railcar to the empty trailer. In the afternoon, the loaded cask was transported to TAN while the empty cask was being reassembled with overpacks for return to TMI-2. Combining these operations saved a considerable amount of time to brief personnel and gather, set up, break down, and store equipment.

The net effect of these three improvements was a reduction in the average time required to handle one cask (i.e., prepare the cask for transfer, transfer the cask from railcar to trailer, transfer the cask to the railcar, and prepare the cask for transport back to TMI) from four shifts to one shift.

There were two other changes implemented during handling of casks at CFA that improved the operations. Work platforms were added to eliminate the possibility of operators slipping off a cask or skid, to provide space for more operators to safely work on a cask at the same time, and to provide better access to the top of the cask, skid, and overpacks. Also, a spreader bar was built that made handling operations for the environmental cover much safer and faster (see Figure 3-10).

3.3.2.2 Transport Between CFA and TAN. The first three movements of the truck transporter with a cask across the INEL had a speed restriction of 10 mph and required nearly three hours to complete a one-way shipment. For the fourth and subsequent movements, a new tractor was procured to pull the trailer. The tractor was geared such that a reasonable speed was either 7 or 15 mph, but not 10 mph. An analysis showed that the speed could be increased to 20 mph without jeopardizing the safety of the shipment, so the maximum allowable speed was increased to 15 mph. Prior to the speed increase to 15 mph, there was difficulty in completing a cask movement in a single day. This change in tractor resulted in completing a one-way shipment in under two hours. The change provided cost savings and more flexibility in scheduling a shipment.



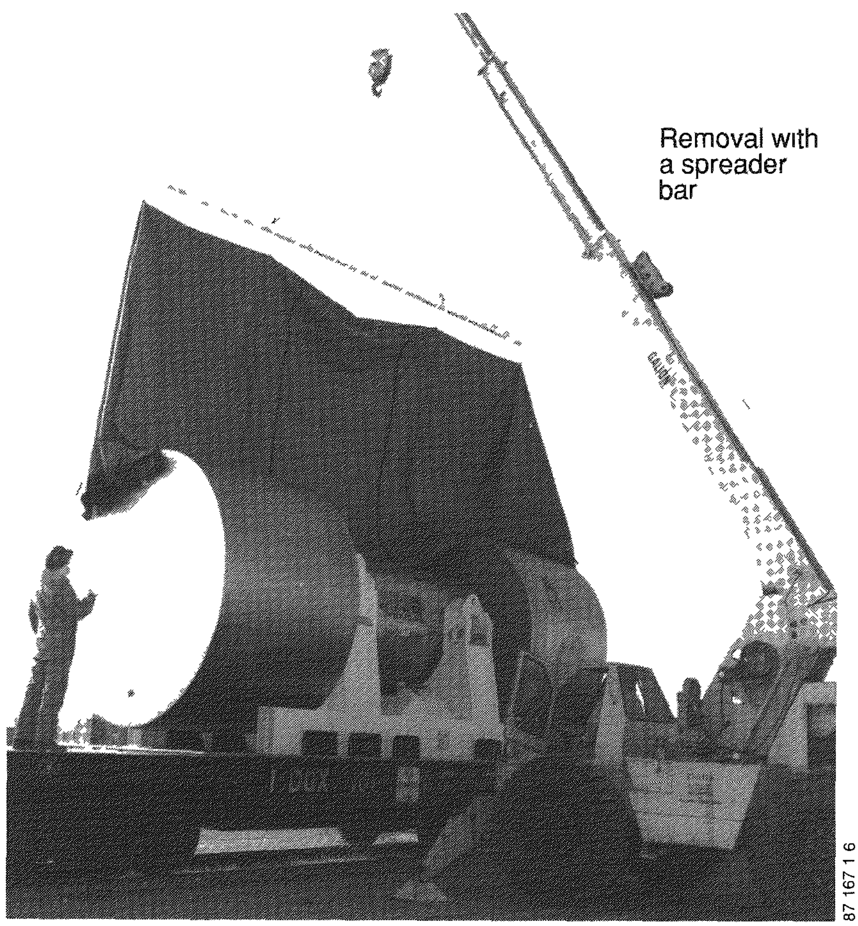


Figure 3-10. A spreader bar made lifting the environmental cover easier.

3.3.2.3 TAN Hot Shop Operations Improvement. Changes in the cask unloading operations in the Hot Shop resulted in the following improvements:

- Cask and ICV bolt holes were covered to prevent contamination.

- Two different lid lift tools were used, one for each lid.

- GPU Nuclear marked the canister number on the side of each canister so that Hot Shop technicians could identify a canister through the gallery windows during unloading.

- The protective sleeve for the ICV sealing surface was modified for easier installation.

- The lid bolts were removed while health physics personnel checked the vent port gas sample for contamination.

- The canisters were moved in a more direct path from the cask to the vestibule pool.

- A breakaway loop was added between the 100- and 10-ton crane hooks to provide a warning to the technicians that the grapple festooning could break if the crane hooks were not adjusted.

- The canister water filling and venting procedures were simplified.

- The mechanics removed and replaced pins for the trunnion tiedown covers in the HECF extension instead of in the Hot Shop, eliminating personnel entries into the Hot Shop.

- The vent port gas sample filter holder was changed from a bolted assembly to a screw type assembly.

- A nonconformance report, written each time a canister was received with contamination levels exceeding those specified in the Canister Acceptance Plan, was replaced by submittal of a letter to GPU Nuclear.

- A tube was added down the center of the lower impact limiter, which allowed removal of water from an ICV canister cavity without removing and then replacing a limiter.

- Use of five 8-hour shifts at the Hot Shop was changed to the use of four 10-hour shifts, which resulted in more productive time each week. There was more time in the Hot Shop before and after lunch breaks each day, one less daily briefing each week, and less time spent preparing for entering and leaving the Hot Shop.

The cumulative effect from incorporating all of the above changes was a net reduction in the time required to perform the cask unloading operation in the Hot Shop. The time required went from four 8-hour shifts (32 hours) per cask to less than two 10-hour shifts (20 hours) per cask.

A change in the canister acceptance criterion for maximum canister weight was negotiated between DOE and GPU Nuclear that resulted in better utilization of both the volume inside the canisters for core debris and the floor area in the Hot Shop storage pool. Originally, to prevent overloading the storage pool floor, EG&G Idaho required that no more than 5% of all canisters could exceed a weight of 2,800 lb in air and no single canister could exceed 2,940 lb. This requirement proved to be unnecessarily restrictive since most of the canisters were below the 2,800-lb limit, which increased the number of canisters needed to contain the entire amount of core debris, and accordingly increased the amount of floor area needed in the pool. A problem with the 5% restriction was that GPU Nuclear was forced to be conservative during the loading of canisters to ensure that canisters close to the weight limit did not exceed 2,800 lb and contribute to the 5% count. The projected number of canisters to contain the core was as high as 400 at about the time of these negotiations. To alleviate these problems, the criterion was changed such that a cask shipment of seven canisters could not exceed an average of 2,800 lb per canister, including weighing equipment inaccuracies (the 2,940-lb restriction for a single canister still applied based on both the cask safety analyses and canister storage module design considerations). This change ensured that the floor load limits were not exceeded while allowing more efficient utilization of the usable volume in each canister and minimizing pool floor area needed for storage of the entire core.

3.3.3 Off-Normal Operations. There were numerous off-normal events and special issues that resulted in delays, required special procedures, or caused investigations. Appendix J is a summary tabulation of notable information for each cask load. The following discusses some of the important off-normal events and issues.

3.3.3.1 Weather-Related Delays. As previously stated, the cask handling operations at CFA were conducted outside and were subject to weather delays. Weather conditions that prevented handling a cask at CFA were winds greater than 20 mph and an outside temperature less than 0°F. Considering the variety and historical harshness of weather conditions at the INEL, actual delays during the four-year campaign were minimal. There were less than 10 delays due to winds and only one due to a below 0°F temperature. Although there were wind-related restrictions, wind speeds up to 20 mph had no noticeable effect on the handling of the very heavy casks and had only a minimal effect on the handling of the bulky but heavy overpacks. However, winds in excess of only 10 mph had a significant effect on the disassembly and reassembly of the light weight and large surface area cask environmental cover. The cover was a vinyl coated nylon tarp, which acted as a sail and provided the most hazardous operating conditions for workers handling the casks at CFA.

During transport to and from TAN, there were no delays caused by snow or ice on the roads; however, on occasion, shipments were preceded by sanding trucks and snow plows.

3.3.3.2 Railcar Adjustment. Difficulty was encountered during the reinstallation of the overpacks after cask load 6. The railcar was not level side-to-side, which affected the alignment of the cask lugs and overpack spline during reinstallation operations. The out-of-plum condition of the railcar was referred to the carrier, UP, for inspection and correction. UP determined that the tilt was caused by lube disks under the railcar bed, which were too hard and failed to compress as designed. The disks were replaced with a different lube material that compressed properly[57] and corrected the condition during later operations.

3.3.3.3 Cask Inspection Following Off-Normal Event During Ninth Rail Shipment. As discussed in Section 3.2.6, the train locomotive struck a stalled automobile at a crossing in St. Louis, Missouri, during the ninth rail shipment. Even though there was no visible damage to the TMI-2 railcars and casks at the accident scene, there was a careful and thorough inspection upon arrival at the INEL to determine if hidden damage had occurred as a result of the incident. No damage was detected.

3.3.3.4 Trailer Walking Beam Failure. During transport of the 27th cask load from CFA to TAN, a suspension component, called a walking beam, on the right rear end of the TWAMCO trailer failed. The shipment was stopped and security personnel were posted at both ends of the vehicle until the walking beam failure was resolved. An Unusual Occurrence Report was prepared.[58] An engineering analysis was conducted, and two new, stronger, walking beams were procured from TWAMCO and were installed on both sides of the trailer. Two new pillow blocks, used to hold the walking beams in place, were also installed. A thorough inspection of the entire trailer was performed before the transport continued to TAN. This event was not a threat of any type to the cask and its contents, but it was a nuisance in the sense that security personnel were required to man the location for traffic control until the failure was corrected from May 26, 1988, to June 10, 1988.

3.3.3.5 Road Construction. There was major road construction along the route between CFA and TAN during the summer months of 1989 and 1990. This included major road bed preparations. To ensure that transport activities were not stopped and that the safety standards for transport of hazardous materials were not compromised, interim transport requirements were established. All shippers affected by the construction were consulted to identify the expected number of shipments, schedules, and any special requirements. A supplemental Transport Plan for Road/Construction Periods was prepared and approved by DOE-ID. The plan outlined road condition requirements, speed restrictions, escorts, and procedures for construction workers operating heavy equipment when encountering a radioactive shipment. As a result of the careful preplanning and precautions, delays for the TMI-2 core debris shipments were minimal and there were no incidents.

3.3.3.6 Shield Plug/Lower Impact Limiter Modification. There were two types of impact limiters protecting the canisters within the ICV of the casks. Both would have protected a canister from axial impact loads during a transport accident. The upper impact limiter was attached to a shield plug that reduced radiation exposures to workers to acceptably low levels during cask loading and unloading operations. The original design for both types of internal impact limiters used an epoxy bond to attach a thin metal sheet to the honeycomb energy absorber material. Moisture introduced into an ICV canister cavity on the external surfaces of a canister caused the epoxy bond to fail, resulting in a time-consuming, difficult, and frequent job of repairing the limiters. This condition was corrected by redesigning and rebuilding both types of impact limiters. A subcontract was awarded to develop a methodology for welding a thin stainless steel sheet (called "skin") around the outside of a limiter and to perform the actual welding. A new plasma arc welding technique using qualified welders was used to rebuild the redesigned limiters. One of the difficulties with this task was in preparing the limiters for repair. This involved decontamination efforts, transport to the contractor for repair, and replacement during cask operations at TAN and TMI-2. In addition to welding the skin to the top and bottom plates on the limiters, a tube was added through the center of the lower impact limiters to allow removal of water from the bottom of an ICV cavity without removing a lower limiter.

3.3.3.7 Canister Thaxton Plugs. On August 8, 1988, Hot Shop technicians noticed bubbles coming from filter canister F-427 during the water-filling process. The Thaxton plug in the outlet port had broken and was laying in pieces on the canister's upper head. There was no increase in radioactivity detected by air monitors, and no detectable additional personnel exposure resulted. An Unusual Occurrence Report was written.[59] A thorough inspection of the other Thaxton plugs in canisters in storage at the INEL uncovered a total of four damaged plugs. All four plugs were immediately replaced.

Thaxton plugs were used by GPU Nuclear at TMI-2 to seal the process flow inlet and outlet ports of both filter and knockout canisters. Thaxton plugs were made from 400 series stainless steel with a pliable gasket material, a conical shaped bolt, washers, and an attached nut. The bolt passed through the center of the pliable material. As the nut was tightened, the cone was pulled into the center of the pliable material, expanding its outer diameter to create a seal. A stress analysis of the plug indicated that excessive torque was being used to install the plug. A metallurgical evaluation of the plug determined a tensile, rather than fatigue failure occurred, but that the material did meet the heat treatment requirements of the manufacturer, Thaxton, Inc. A feature of the plug design is that the bolt head was also counterbored and threaded for use by a tool to extract an installed plug. The primary fracture occurred at the sharp transition of the counterbore and may have been initiated by a small quench crack. The counterbore was also too deep, meaning the tightening nut worked against thin walls.

Originally, the hex nut on a plug was tightened to 200 ft-lb torque, causing the ring of pliable material to expand and seal the port. After the occurrence at the INEL, the plugs were reevaluated and redesigned, and the torque was reduced to 45 to 50 ft-lb. All Thaxton plugs in canisters at TMI-2 were replaced using newly designed plugs torqued to the lower value. All subsequent canisters requiring Thaxton plugs used the new design.

A total of 6 knockout and 20 filter canisters had already been received at the INEL before the damaged plug was found. All of the Thaxton plugs in those canisters were replaced with new plugs torqued to the lower value. A Thaxton plug tool was designed and fabricated, and a DOP was prepared for the replacement operation. Changeout of the plugs went fairly quickly until work on the last plug began. The entire nozzle, with the overtorqued plug still inside, unscrewed from the head. A Non-Conformance Report was written, an engineering evaluation was performed, and the DOP was revised to correct the situation. With the nozzle out of the canister and away from the pool area, the overtorqued plug was removed and a new plug was installed at the lower torque. The nozzle, with new plug installed, was returned to the pool and reassembled into the canister head. There was no detectable pool contamination from any of these Thaxton plug failures and replacement operations.

3.3.3.8 Third Cask Interference. Use of the third cask began with the 12th rail shipment (19th cask load). During removal of the cask from the skid for the first time in the Hot Shop, one of the overpack attachment lugs gouged a trunnion support arm on the skid. A Non-Conformance Report was written and a disposition was received from the cask owner, NuPac. The cause of the damage was a very tight fit between the cask and skid. A die-penetrant check of the tiedown lug on the cask was performed and the gouged area on the skid was ground smooth followed by a magnetic-particle check of the affected area. The gouging had not affected the integrity of the cask or skid. To prevent continued interference, NuPac provided instructions to EG&G Idaho for removing up to 1/8-in. of material from the skid.

3.3.3.9 Facilities Issues. Examples of Hot Shop facility-caused delays to TMI-2 cask unloading operations were requalification of the H&V system following an upgrade; O-man replacement; bridge crane modifications; and failure of the gamma spectrometer, which was required to be operational by the OSRD for the facility, and had to be repaired before restart of the unloading operations.

3.3.3.10 Canister Grapple. The umbilical cord between the control system and the canister grapple was severed several times during initial transfers of canisters from casks to the TAN Hot Shop vestibule pool area. The umbilical cord hung between the hook of the 100-ton overhead crane and the grapple that was supported by the hook of the 10-ton overhead crane. The 100-ton crane hook was used to carry most of the weight of the cord, thus reducing the side loading on the grapple. During the transfer operations, the operators concentrated on moving a canister with the 10-ton crane and failed to notice the cord hanging up on objects or stretching between the two cranes. In several instances, the cord was broken, causing a delay while the cord was repaired. This problem was corrected by including additional warnings in the DOPs and by adding a "breakaway" loop in the cord between the two cranes, which would break to provide a visual warning to the technicians.

3.3.3.11 Canister Contamination. The INEL had very restrictive removable contamination limits on the canisters: 10,000 dpm/100 cm^2 beta-gamma and 250 dpm/100 cm^2 alpha. GPU Nuclear passed each canister through a decontamination spray ring before loading it into a cask. However, because most canisters' external radiation dose rates were very high, hands-on smears to obtain swipes to determine removable contamination levels were not possible at TMI-2 because of GPU Nuclear's efforts to keep worker doses as-low-as-reasonably achievable. The INEL was able to use the O-man to take smears of the external surface of a canister remotely as each was removed from a cask. The INEL did not reject canisters that exceeded the limits; however, GPU Nuclear was notified so that adjustments were made in their attempts to decontaminate canisters adequately.

A number of experiments with an empty canister were conducted by GPU Nuclear to improve the canister decontamination procedures. These consisted of (a) using a high-pressure water spray ring system, which failed by a factor of 50 to meet the EG&G Idaho criteria;[60] (b) multiple soakings of a canister in hydrogen peroxide H_2O_2 solutions, followed by H_2O_2 solution spraying, and hand wiping, which indicated that another factor of two for decontamination would be required;[61] (c) hand wiping and cleaning with a bristle brush, which showed that hand wiping was the most effective, but still did not meet the requirements;[62] and (d) using a decontamination spray ring with cold water and heated water, which showed that heated water was best and came closest to meeting the requirements.[63]

GPU Nuclear settled on using the decontamination spray ring with borated hot water for cleaning loaded canisters. Because of the extremely limited capability to perform smears on loaded canisters, GPU Nuclear requested and received feedback from the INEL regarding surface contamination levels. The problem was never entirely eliminated but was significantly improved by GPU Nuclear's efforts. Continually working to achieve the restrictive INEL loose contamination limits was successful in minimizing contamination levels inside the casks, which was important to GPU Nuclear since their operations were performed in the truck bay shared by Units 1 and 2. The low contamination levels also minimized spread of contamination in the TAN Hot Shop and storage pool areas.

3.3.4 Additional Operational Considerations. There were several activities and issues identified during the core debris receipt and storage campaign that added to the complexity of the program. The following is a discussion of some of the most significant activities.

3.3.4.1 Canister Module Poison Plate Inspection. The canister storage modules have poison plates incorporated within the walls to reduce neutron interactions between canisters. Per DOE's requirements for criticality safety, the plates must be periodically inspected while canisters are stored in the pool. One plate at a time must be removed from a module and positioned on a special table. Neutron radiography inspection equipment was passed over both sides of the plate to determine the continuing integrity of the plate. The neutron radiography technique measured the number of neutrons passing through a poison plate. Results were compared with the number of neutrons passing through a sample of known thickness and composition of the poison material (polyethylene and Boraflex^{TM}). A visual inspection of each plate was also performed.

When the inspection process was completed, the poison plate was returned to the original configuration in the module. During a poison plate inspection, the module latching arm, which secures a canister in the module, the poison plate lock mechanism, and the canister vent tubes were also inspected. This activity will continue as long as the canisters are stored in the Hot Shop storage pool.

3.3.4.2 Cask Lid Chamfer. The two DOE-owned casks, NuPac 125-B cask serial numbers 001-IT and 002-IT, were fabricated with 0.33 cm (0.13 in.) 45-degree chamfers at the bolt hole seating surface area of the inner containment vessel lids, which led to premature deterioration of the lid bolts. These chamfers were eliminated by weld buildup and remachining the bolt seating surfaces and holes. The lids were cleaned and reworked in a shop at the INEL. Eliminating of the chamfers provided more seating surface area for the lid bolts, which solved the bolt seating and wear problem. This modification did not require NRC approval since drawings in the SAR do not contain this level of detail.

3.3.4.3 Microorganism Studies. During the TMI-2 defueling operation, microbial organism growth became a problem in the reactor vessel. Concern that the microbes may corrode the canister components and compromise the integrity of the canister while in long-term storage at the INEL prompted several evaluations. These were performed to identify the type of microbes and to determine the potential for corrosion activity on and in the canisters. Efforts at the INEL included video inspection of the interior of canister D-136B and placement of test coupons in that canister for long-term observation; removal and inspection of the contents of the hydrogen-peroxide-treated canister D-153; laboratory studies of cultured microbes and evaluation of coupons in the cultures; and analysis of the TAN-607 Water Pit water for microorganisms. These studies were terminated after GPU Nuclear developed an effective method for controlling the microorganisms using a hydrogen peroxide treatment.

3.3.4.4 Gas Sampling. In support of a GPU Nuclear request for a change to canister dewatering criteria, NRC agreed to allow the INEL to perform extended-duration gas monitoring on a canister from each rail shipment. Gas samples from the monitored canisters were obtained over time to verify the operability of the recombiner catalysts. A total of nine canisters were sampled over several weeks as part of this study. Table 3-14 identifies each canister sampled and the results of the gas sample analysis. The INEL gas sample results confirmed the conservatism in the projected allowable safe shipping duration for each canister, which was determined by gas samples taken at TMI-2 before shipment. Appendix K is a letter from GPU Nuclear to NRC transmitting gas sample data and requesting approval to stop sampling canisters at the INEL.

3.3.4.5 Additional Pool Space. Based on GPU Nuclear's estimate in the core contract of 238 canisters to contain the core debris, the INEL originally planned to receive up to 250 canisters. This number of canisters could have been placed on one side of the TAN storage pool. However, midway through defueling operations, GPU Nuclear determined that the total number of canisters could exceed 350 canisters. This meant additional storage space had to be made available on the other side of the pool. A special container was designed and fabricated to hold miscellaneous material already in storage on the opposite side of the pool floor. The material was loaded into the container, which provided more pool storage space for canisters, and prevented the material from potentially tipping or sliding into the canister storage modules during seismic activity and causing damage.

3.3.4.6 Cask Seal Issue. In July of 1988, NuPac informed EG&G Idaho of an impending issue regarding the neoprene seals used to seal the lids of the NuPac 125B shipping casks. NuPac identified that similar seals of neoprene material had failed to maintain the demanding leak-tight (10^{-7} atm-cm^3/sec) seal leakage rate requirement under normal or hypothetical accident conditions at very cold temperatures (-40° or -29°C, respectively) in a test setup for another NuPac project. The test conditions were established so that an inner disk, representing a lid with seals in a bore, was purposely shifted to one side of the bore, which resulted in an increase in seal compression on one side with a corresponding decrease in seal compression on the opposite side.

Although the possibility of such extreme cold temperature conditions during an accident involving a TMI shipping cask was considered remote, the issue of seals had notable visibility following the Space Shuttle Challenger disaster, and NRC was evaluating the impact of the NuPac data in relation to cask seal leakage past seals in various cask systems. DOE made a decision to interrupt the shipping campaign, and authorized NuPac to perform additional seal testing efforts specific to the NuPac 125B seal geometry (see Section 3.4.1 for NuPac contract change). The result of this testing effort was the identification of a replacement neoprene seal material that met requirements and a revision to the cask SAR to include specific callouts of the acceptable material. The TMI-2 core debris shipping campaign was interrupted from July to mid-December (between the 16th and 17th rail shipments) to resolve the seal issue. Changeout of seals in loaded casks at TMI-2 by GPU Nuclear was required, and there was considerable interaction between EG&G Idaho quality assurance personnel and the new seal vendor.

3.3.4.7 Scoville Branch Line Rail Repair. Starting in May 1987, UP placed speed restrictions of 20 mph on train traffic for the Scoville Branch Line [Blackfoot, Idaho, to Scoville (INEL), a distance of 42 miles]. This restriction was required because of needed maintenance and repairs to trackage and roadbed. Portions of the rails were replaced, the roadbed was redone in places, railbed crossties were replaced, and other repairs were made. Following the repairs, which were completed in January 1988, the line was rated as an FRA Class Three track and speeds up to 40 mph were allowed. The speed restrictions and repair activities did not cause major inconvenience to the shipping campaign.

Table 3-14. Summary of canister gas samples at the INEL.

			Canister pressure/cumulative days closed								INEL gas sample chemical analysis (% volume)															
			INEL								Hydrogen				Nitrogen				Oxygen				Argon			
			First		Second		Third		Fourth																	
Canister number	Rail ship ment	TMI (psi)	psia	days	psia	days	psia	days	psia	days	First	Second	Third	Fourth	First	Second	Third	Fourth	First	Second	Third	Fourth	First	Second	Third	Fourth
D-144[a]	—	29 54	26 33	147	—	—	—	—	—	—	0 77	—	—	—	0 90	—	—	—	0 08	—	—	—	98 20	—	—	—
D-148	4	29 52	29 13	26	28 83	48	—	—	—	—	1 15	1 47	—	—	0 36	0 70	—	—	0 07	0 13	—	—	98 40	97 70	—	—
D-145[b]	5	20 54	29 33	27	—	—	—	—	—	—	0 74	—	—	—	0 585	—	—	—	0 09	—	—	—	98 6	—	—	—
D-180	6	29 38	18 33[c]	27	19 33	205	—	—	—	—	1 23	9 05	—	—	1 07	3 75	—	—	0 13	0 02	—	—	97 5	87 19	—	—
D-162	7	29 27	29 33	36	28 33	—	—	—	—	—	1 005	1 01	—	—	4 36	2 22	—	—	1 02	<0 01	—	—	93 53	96 74	—	—
D-188	7	29 36	29 08	16	28 83	181	28 33	88	27 33	168	1 165	2 43	3 30	5 09	0 50	1 95	2 16	1 81	0 05	0 305	0 26	<0 01	98 26	95 29	94 25	93 10
D-207	8	29 34	28 83	20	27 33	56	—	—	—	—	0 20	0 46	—	—	0 475	3 82	—	—	0 04	0 72	—	—	93 40	89 66	—	—
D-267	9	29 33	28 83	20	27 33	76	—	—	—	—	0 12	0 25	—	—	0 90	0 52	—	—	0 17	0 01	—	—	98 80	99 17	—	—

a Canister D-144 gas was sampled before NRC requirement (but the data were included in the gas sample information to NRC)

b Only one sample was taken from canister D-145 at the INEL

c INEL pressure gage malfunctioned on canister D-180

3.4 Contract Changes

During the core debris transport campaign, minor changes were required to each of the major contractual arrangements established by EG&G Idaho to accomplish the shipping program. NuPac was requested to provide continuing support for cask licensing activities. GPU Nuclear requested changes to the core contract to accommodate a far greater number of canisters than the 238 originally anticipated to be needed. The contracts with the railroads were modified to reflect the conditions each side could accept and cost increases over time.

3.4.1 NuPac Support to Cask Licensing. During the transport campaign, NuPac provided continuing technical support for use of the 125-B casks. In September 1986, a new contract was issued by EG&G Idaho for $12,500 to prepare Revisions 4 and 5 of the cask's SAR (see Appendix I). The first modification to the contract incorporated a change for $13,000 to prepare Revisions 6, 7, 8, and 9 to the SAR. The second contract modification was for $50,000 to perform an initial phase of the cold temperature seal testing program and to prepare Revision 10 of the SAR. The third contract modification was for an additional $50,000 for expansion of the seal test program and delivery of six sets of seals of the material passing the cold tests. The final modification under the contract was for $10,000 to prepare Revision 11 of the cask's SAR.

In March 1991, EG&G Idaho entered into a third contract with NuPac to prepare a consolidated application (SAR) for the renewal of the CoC for the 125-B cask. The consolidated SAR merged the many supplements to the original SAR and produced a single coherent document.

3.4.2 Changes to the DOE/GPU Nuclear Core Contract. During the course of the TMI-2 core debris shipping campaign, the core contract was the subject of much communication between DOE, EG&G Idaho, and GPU Nuclear through change notices regarding spending ceilings, changes to canister acceptance criteria, and related issues. The major interaction involved the only amendment to the contract. The issues involved in this amendment were large and many, and the negotiations leading to concluding this amendment were extensive. The issues basically involved DOE costs to GPU Nuclear for services to receive core materials where both the number of canisters to be delivered and the delivery completion date were significantly different from the original basis of the core contract.

The original estimate and planning basis for the number of canisters to contain the TMI-2 core debris was 238. However, early in 1987, it became apparent that more canisters would be needed than originally projected since packing efficiency, especially in filter and knockout canisters, was less than expected. Further, the targeted completion date for delivery to DOE by December 31, 1987, could not be achieved because of problems and delays in completing defueling. As specified in the core contract, delivery after March 31, 1988, subjected GPU Nuclear to pay for full recovery of DOE's costs. The late completion date impacted shipping, receipt, equipment, facility, and manpower requirements for DOE. A modification to the contract was approved by both parties on July 21, 1987, with an effective date of January 11, 1987. This modification incorporated the following changes:

- GPU Nuclear assumed the expense for the railroad companies special train service charges beginning with the fourth shipment on January 11, 1987. (EG&G Idaho paid the total invoice received from the railroads; a copy of the invoice was sent to GPU Nuclear highlighting the expedited service charges, whereupon GPU Nuclear reimbursed EG&G Idaho.)

- All other conditions of the original contract were binding until the INEL had received 264 canisters. At that time, the amount per canister increased to $31,700 until GPU Nuclear transferred a total of 288 canisters (the number of canisters which fit in one-half of the TAN storage pool).

- After the INEL received 288 canisters, the amount per canister became $45,500 through to completion of the shipping campaign.

- In addition, GPU Nuclear paid a one-time charge in FY 1989 of $130,500 for storage pool safety analyses and preparation and relocation of materials in the TAN-607 pool to make more space available.

As previously noted, GPU Nuclear had determined that expedited train service would be needed to achieve their defueling schedule objectives and agreed to pay for the service. The effective contract modification date of January 1987 incorporated expedited service charges on GPU Nuclear's behalf, starting with rail shipment 4.

The original contract between DOE and GPU Nuclear, as discussed in Section 2.1.1, specified a payment total of $7,351,128. The subtotal for additional work in the contract amendment, which raised the overall effort to 22 trains, 49 cask loads, and 342 canisters, was $3,372,200. Thus, the total contract value was $10,688,328. GPU Nuclear also paid an additional $1,037,500 in expedited train service charges.

3.4.3 Changes to U.S. Tool and Die Contract. As a result of the increase in the number of canisters, changes were also required in the U.S. Tool and Die contract for the number of canister storage modules provided to the INEL and delivery dates. This contract modification was relatively straightforward although there were negotiations for price increases for the added modules.

3.4.4 Changes to Rail Carrier Contracts. As discussed in Section 2.8, by late 1985, as the start of the shipments approached, the EG&G Idaho traffic manager and various other EG&G Idaho, DOE, and GPU Nuclear personnel attended several meetings with UP and Conrail to discuss preparations for the shipments. Once the first few shipments were completed, the later contract negotiations between EG&G Idaho and the rail carriers were handled largely by the traffic manager through the end of the campaign.

Two meetings were held before the contract negotiations were completed. One was in Omaha, Nebraska, with UP in October 1986, and the other one was in Washington, D.C., with Conrail in November 1986. Meetings with the rail carriers after the start of the shipping campaign can best be characterized as attempts to resolve differences in DOE-desired services and the carriers' positions as reflected in their ongoing operations. Issues included special train service, inspection arrangements, any-day pickups at TMI-2, and time-of-day transit through St. Louis. The only notable contractual changes involved yearly extension of contracts and changes to pricing from rate increases.

3.5 Institutional Issues During the Campaign

Institutional issues and public relations during the campaign were significant in scope and accounted for a good share of the shipping team's efforts. Some of the activities discussed below are extensions of activities initiated before the start of the campaign, but are discussed herein because of their ongoing nature.

3.5.1 Level of Interest. Initial interest by news media in the transport campaign was on a national level. During July 1986, when shipments from TMI-2 began, nearly 200 news media inquiries were handled by the spokesperson. While national interest subsided after the first shipment, news media at many locations along the route continued to cover the campaign. After several shipments, interest from news media was still high in the Harrisburg, Pittsburgh, St. Louis, and Idaho Falls areas. Total news media contacts for the first two years of the program numbered more than 500.

Figure 3-11 illustrates the number of news media and non-news media contacts handled from April 1986 through August 1988 by the program spokesperson, which would not be nearly all-inclusive, however. An inquiry requiring research and reply was counted as one contact, or a communication initiated by the spokesperson was counted as one. Non-news media contacts

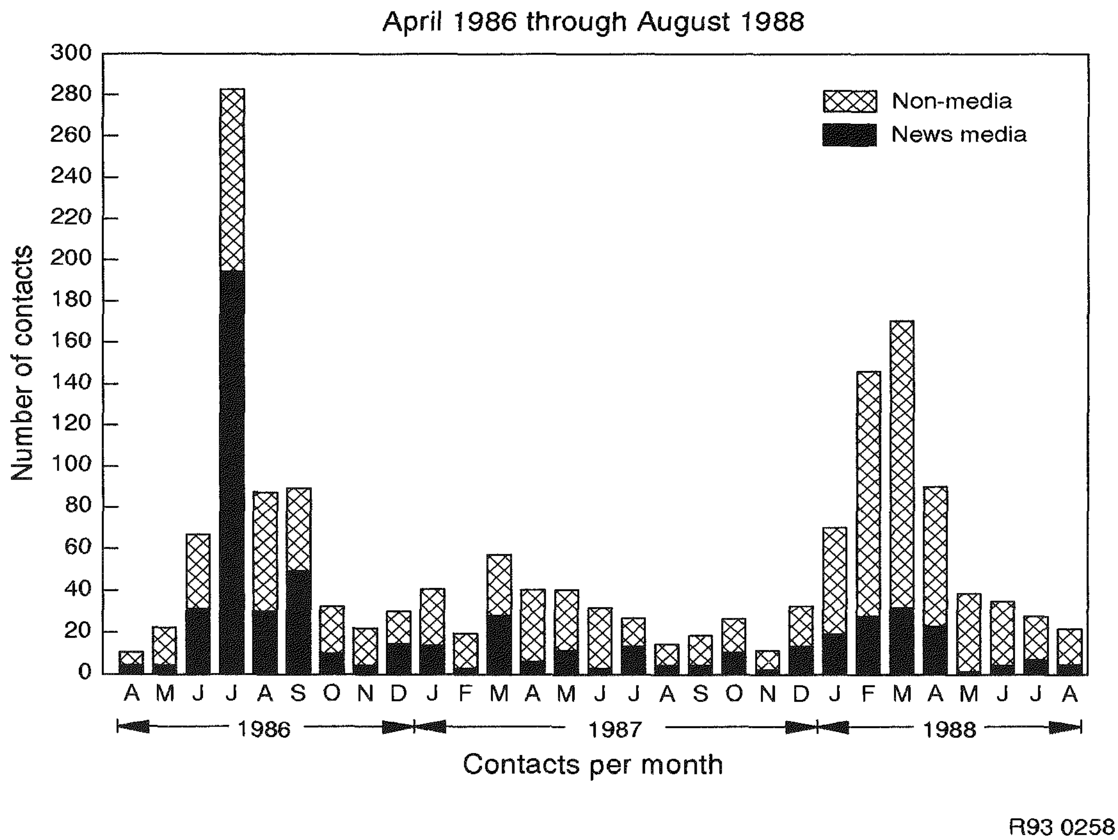


Figure 3-11. Number of media and nonmedia contacts.

included telephone and personal contacts with State and local officials, DOE-HQ, other Federal agencies, Congressional staff, industrial representatives, special interest groups, and private citizens. The program treated each and every one of these contacts/requests as a priority issue and made concerted efforts to interface or reply factually and completely as early as feasible. Since many written requests went directly to DOE-HQ offices, the program received invaluable support from those offices in replying to the requests. Many of the requests were for extensive amounts of information and required considerable effort to respond. A sampling of a number of such requests is provided as examples in Appendix M along with corresponding DOE responses. Since many concerns expressed or requests for information were similar and addressed the same issue, a response could sometimes be selected from a set of common or standard responses.

Congressional inquiries to seek information or responses to concerns of their constituents were frequent. At least fifteen members of the House of Representatives addressed one or more letters to the Secretary of Energy and other responsible officials during the campaign. Seven or more senators were similarly involved with several, such as John Heinz (deceased), Pennsylvania, and John Danforth, Missouri, having multiple involvements. John Danforth prepared about ten letters of inquiry for example. And, at least six governors were actively involved in questioning conduct of the campaign.

Data in Figure 3-11 show that news media and non-news media interest was highest at the beginning of the campaign, declined thereafter, but increased again several times during the campaign. Those later increases occurred in conjunction with certain events that were sometimes directly related to the transport campaign and at other times only indirectly related (see Section 3.2.6 for an explanation of events associated with each shipment in the TMI-2 campaign). Interest was generally higher during months when shipments were made and was occasionally higher during weeks immediately preceding Federal, State, or local elections. In response to requests from several members of Congress, DOE curtailed shipments before and after elections and also gave attention to scheduling to avoid major holidays. Although not official DOE policy, similar curtailment considerations prevailed in response to a City of Indianapolis request for no shipments during the Tenth Pan-American Games, August 8–23, 1987.

High interest levels in July 1986 resulted from public meetings held before the start of the campaign, a press conference, issuance of press releases, and the first shipment. News media interest increased in March 1987, after a train hauling TMI-2 core debris collided with an automobile in St. Louis. Although the train was fault-free, this event also led to increased interest by several members of Congress and some local officials.

Interest continued at a high level in April and May 1987, because of a derailment of a Conrail freight train near Pittsburgh, Pennsylvania, which led to the evacuation of approximately 15,000 people. Although that accident was not related to the TMI-2 shipments, it occurred on track used for those shipments and led to speculation by the public that the accident would have been worse had it involved a train carrying TMI-2 core debris. An increase in news media attention was manifest in July 1987, the one-year anniversary of the start of the campaign, when special interest groups in St. Louis and Pittsburgh held protest rallies to commemorate the event.

News media and non-news media interest increased again in December 1987, when the first triple-cask shipment passed through St. Louis during rush-hour traffic. Interest continued at a higher level in January 1988, when a UP freight train derailed on the UP mainline used by the TMI-2 trains on a bridge across the Merrimac River [about 19 km (12 mi) west of Kirkwood, Missouri]. News media asked the question "What if it had been the TMI train?"

In February 1988, a TMI-2 shipment passed through St. Louis with an improperly placarded buffer car. The incident led to protests from special interest groups, increased news media coverage, and inquiries from local officials and several members of Congress. In March, 1988, the FRA began an investigation into the incident and DOE made several concessions because of Congressional requests and public concerns (see Section 3.5.4.2, FRA Investigation).

In April 1988, partially in response to concerns in the St. Louis area, the Public Relations Plan was amended to allow DOE and EG&G Idaho to begin a more proactive role in disseminating information on the campaign.[64] The amended plan allowed more emphasis to be placed on: (a) developing and maintaining good communications and relationships with concerned State and local officials; (b) initiating and conducting briefings for public officials or news media; and (c) initiating and attending public meetings. DOE and EG&G Idaho made extensive efforts to address concerns of local and State officials, members of Congress, news media, and special interest groups. These efforts included several meetings and briefings with mayors and other public officials in the St. Louis area; briefings for concerned members of Congress; briefings for news media; DOE emergency response training in the St. Louis area; and a joint meeting in Washington, D.C., with several St. Louis area mayors and members of special interest groups.

A relative decrease in news media and non-news media interest was evident in May 1988. That decrease was attributed to the initiation of proactive public relations activities the preceding month. The number of non-news media contacts was higher than the number of news media contacts from May through August 1988 because of a continuation of closer communications with State and local officials.

3.5.2 Major Concerns and Resolution. Several issues dominated concerns raised by the public during the transport campaign. Those concerns and their resolutions are discussed below:

1. Questions on selection of the rail route were asked before the campaign started and continued until about April 1988. There was notable opposition to the route through major cities, particularly Pittsburgh, Pennsylvania, and St. Louis, Missouri, but strong opposition developed in small communities also. Some parties alleged that route selection was haphazard or based on political considerations. DOE and EG&G Idaho spent considerable time discussing that concern. Criteria used in route selection were discussed: highest quality track, shortest time in transit, shortest distance, lowest number of switches, and minimizing population where possible. Documentation on the route selection process was provided to interested parties. Explanations of the route selection process showed that politics was not a factor in selecting the route. A July 7, 1987, proposal from the State of Missouri's Emergency Management Agency for rerouting the TMI-2 trains became a subject of much evaluation. The proposed route involved a bypass of the City of St. Louis by using a transfer from Conrail to Norfolk and Southern at Fort Wayne, Indiana. The route would then proceed through several cities less populated than St. Louis, resulting in passing a smaller total population than on the original route. As explained to the proponents of the route change, the proposed route was not appropriate for a number of reasons. The bypass route would have increased the time and distance compared to the existing route; added the complications of a third rail company (train switches, costs, contracts, and training); had more miles of lower quality tracks than on the existing route; required changes to Illinois and Indiana inspection procedures and plans; required FRA inspection and validation of the tracks on proposed route; added a new set of cities and communities (expected to be equally opposed to TMI-2 train transit); and probably impacted the economic and schedular basis of the DOE/GPU Nuclear core contract agreement. Throughout the shipping campaign, other proposals regarding routing changes were received from time to time, but are not mentioned in this report because they were similarly considered, and were likewise inappropriate and essentially unconstructive. The document that closed the issue on route selection was a DOT review of the TMI-2 rail route requested by Senator John Danforth through Secretary of Energy John S. Herrington (discussed in Section 3.5.4).

2. DOE did not prepare a route-specific EIS for the TMI-2 transport campaign, but took exemption under the categorical exclusion allowed under the regulations because the activity was bounded by previous EISs. Because no route-specific EIS was performed, some public officials, special interest groups, and other organizations opposed to the shipping campaign alleged that DOE was not in compliance with the National Environmental Policy Act of 1969. This became a focused issue during the campaign on a number of occasions, with attempts to stop the shipments until a route-specific EIS could be completed. DOE explained the basis for categorical exclusion through correspondence, with a fact sheet, and at meetings. Those explanations helped to avoid several threatened court actions. (See Mary L. Walker to Vicent C. Schoemehl letter dated August 13, 1987, Appendix G, for a copy of representative correspondence on this issue.)

3. Concerns about Congressional and statutory authority for the transport campaign surfaced in early 1988 primarily because of inaccurate claims made by special interest groups. To prove statutory authority, DOE cited the Atomic Energy Act of 1954, which allowed acquisition of radioactive materials for research. To prove Congressional authority, DOE provided documentation of Congressional testimony and funding authorizations, wherein DOE informed

Congress of its intent and Congress authorized expenditure of funds for the activity. By carefully explaining authority and by providing documentation when appropriate, DOE and EG&G Idaho laid to rest most concerns on this issue.

4. Questions about design and safety features of the NuPac 125-B rail cask were raised before the start of the campaign and persisted through 1988. Most interested parties were satisfied with explanations from DOE and EG&G Idaho. However, special interest groups continued to question cask design and regulatory requirements. To address concerns on this issue, DOE and EG&G Idaho used documentation, fact sheets, and videos showing drop tests of the quarter-scale cask model. One comprehensive document related to this subject was the response to a critique authored by Marvin Resonikoffof the Sierra Club Radioactive Waste Campaign (see Section 3.5.5 for further discussion).

5. Concerns about emergency response capabilities of Federal, State, and local agencies were raised in Pittsburgh, Pennsylvania, in the spring of 1987 and in St. Louis, Missouri, in early 1988. Written and verbal explanations of the capabilities and roles of emergency responders helped satisfy part of those concerns (see Section 2.10.4 for additional information on campaign emergency response provisions). Also, DOE sponsored several emergency response training seminars (workshops) in response to requests from members of Congress and State officials, and those seminars proved beneficial in satisfying concerns. Workshops were conducted near St. Louis, Missouri, on April 26, 1988, and Kansas City, Missouri, on June 7, 1988. The typical format included opening statements or comments by the requesting authority (legislative or local officials); a short briefing by a DOE and/or TMI-2 programmatic representative on the TMI-2 shipping activity and on DOE shipping procedures in general; and the Emergency Response Workshop by Science Applications International Corporation (SAIC) under contract to DOE. SAIC also conducted a workshop in Boise, Idaho, on August 6, 1988.

6. Concerns about movement of TMI-2 trains through St. Louis during peak traffic hours became a focused issue in late 1987 and early 1988 after several TMI-2 trains passed through the city during morning rush-hour traffic. DOE agreed in April 1988 to not move trains through the city during rush hours by modifying the transport schedule (see Section 3.5.4.2, for further discussion on this issue).

   Also of concern to some of the public and officials in the City of St. Louis, Missouri, was the first shipment with three casks made in December 1987. City officials indicated that they had had no advance knowledge that three casks would be on the train. Actually, the State had been fully apprised and had notified the city, so this was another instance of a communications failure among responsible State/city officials. Some individuals and officials protested three-cask shipments as being a greater risk. However, in subsequent agreements related to the FRA investigations, DOE Secretary Herrington agreed with Senator Danforth (Missouri) to ensure that future shipments would always have three casks as a means to limit the number of shipments and thereby reduce risk to the public. Following these agreements, no further opposition to three casks in one shipment materialized. The complete set of agreements is provided in Section 3.5.2.

7. Questions on general rail safety were raised in Pittsburgh, Pennsylvania, and St. Louis, Missouri, in 1987 and 1988 following train derailments along the same route used by the TMI-2 trains. EG&G Idaho, with assistance from Conrail and UP, answered concerns to reassure officials and the public that rail was a safe mode of transportation. Particularly helpful were tours of rail lines

conducted for concerned officials by railroad personnel.

Public concerns were also expressed in various community and public official meetings. These meetings resulted in a number of resolutions and documents of which a few are described in Table 3-15 and included more completely in Appendix G. These resolutions and documents were widely distributed to legislatures and the press, and considerable effort was expended by the shipping team in communicating responses. Accordingly, Appendix G also includes the principal DOE/EG&G Idaho response or report in several cases. Table 3-15 is representative of meetings that occurred, but is not all-inclusive.

3.5.3 Revisions to Working Relations with the States and Notification Procedures. On March 12, 1987, the DOE-DP Assistant Secretary approved a new pre-notification policy for shipments of unclassified spent nuclear fuel and high-level waste. The new policy required implementation beginning August 1, 1987. Shippers of DOE unclassified spent fuel were to provide advance written notification to the State governor (or governor's designee) before the transport of each shipment within or through a State. The shipper (DOE or DOE contractor) was to comply with the following notification criteria:

- The notification was to be in writing and sent by registered letter-return receipt to the office of each appropriate governor or governor's designee. A notification delivered by mail must be postmarked at least seven days before transport of a shipment within or through the State. A notification delivered by messenger was to reach the office of the governor or the governor's designee at least four days before transport of a shipment within or through the State. A list of the mailing addresses of governors and governors' designees was provided, with updates to the list obtainable from the Director of State Programs, NRC, Washington, D.C.

- The notification was to include the following information:
    - The name, address, and telephone number of the shipper, carrier, and receiver
    - A description of the shipment as specified in DOT regulations 49 CFR 172.202 and 172.203(d)
    - A listing of the routes to be used within the State
    - The estimated date and time of departure from the point of origin of the shipment
    - The estimated date and time of entry into the governor's State
    - A request that the information be protected against disclosure.

- A DOE shipper was to notify, by telephone or other means, a responsible individual in the office of the governor's designee or the office of the governor of any schedule change that differed by more than six hours from the schedule information previously furnished in the written notification.

- Notice of cancellation of a spent fuel shipment was to be made by telephone to each State affected. No written notice of cancellation of a shipment of spent fuel needed to be made to the State. A record of the responsible individual who was contacted about the cancellation of a shipment was to be retained.

The new notification policy was implemented for TMI-2 core debris shipments without major difficulties, although possible deviations in schedule by more than six hours was a real concern because of the complexities of the campaign regarding possible delays (traffic, weather, and so forth). The only real deviation from the policy was in the case of a derailment of a train at Marse, Idaho, during TMI-2 rail shipment 19, which required rerouting the TMI-2 train through the State of Utah. This required an emergency short turnaround notification to Utah, whereupon approval was immediately received.

Table 3-15. Community and other types of public correspondence and meetings.

Date	Community	Issue	Result
May 5, 1986	City of Marshall and other communities in Clark County, Illinois	Safety of TMI shipments	A letter from the Mayor of the City of Marshall to Secretary of Energy Herrington stating in part that "the same precautions that apply to commercial shipments through the State of Illinois should be in effect for shipments made by the Federal Government."
June 1986	City of Webster Groves and University City, Missouri	Safety precautions and related subjects	In consultation with the Mayor of Webster Groves and the Director of Emergency Management for the State of Missouri, Fred H. Entrikin, Jr., the Fire Chief and Director of Civil Preparedness for Webster Groves submitted a letter on June 12, 1986, with a series of questions and requests for information to the EG&G Idaho campaign spokesperson.
July 11, 1986	City of St. Louis, Missouri	Risks and emergency response	The Committee on Health and Welfare of the St. Louis Board of Aldermen introduced Resolution Number 51 aimed at emergency response, environmental health, safety, and fiscal risks of the TMI-2 shipments.
July 14, 1986	City of Pittsburgh, Pennsylvania	Rail route	The City of Pittsburgh formulated and passed a resolution on July 14, 1986, related to the TMI-2 rail routing through the city. The resolution was forwarded to Secretary of Energy Herrington for action (see Appendix G for text of resolution).

Table 3-15. (continued).

Date	Community	Issue	Result
July 22, 1986	City of Webster Groves, Missouri	Routing and risk	The City of Webster Groves adopted a resolution on July 22, 1986, with regards to the TMI-2 transport action. The resolution was transmitted to several State legislatures and sent to DOE through the Office of the Missouri Governor. Text of the resolution is in Appendix G.
September 10, 1986	Forum in the City of Kirkwood, Missouri	TMI shipments	In a letter dated August 14, 1986, City of Kirkwood, Missouri, Mayor Herbert S. Jones inquired if the EG&G Idaho spokesperson would be responsive to an invitation to address concerned citizens regarding the shipments. The request was subsequently coordinated with a request from Congressman Robert Young of Missouri. The forum was held September 10, 1986, in Kirkwood with a DOE/EG&G Idaho team in attendance. See Appendix G for an EG&G Idaho report on the Forum.
November 20, 1986	St. Louis County Municipal League and City of Kirkwood, Missouri	Train service	The St. Louis County Municipal League and the City Council of Kirkwood both passed a resolution recommending that DOE and DOT keep other kinds of cargo off trains carrying shipments of radioactive debris from the TMI Nuclear Plant in Pennsylvania. The resolution was directed to having the TMI shipments handled with dedicated trains. The resolution was submitted by Phyllis Evans, a member of the Kirkwood City Council. The resolution was widely distributed and forwarded to Secretary of Energy Herrington by Senator John Danforth, Missouri.

Table 3-15. (continued).

Date	Community	Issue	Result
			NOTE—This resolution also involved UP officials and the FRA of DOT. The issue of dedicated trains resulted from the City of Kirkwood forum on September 10, 1986, wherein the issue of dedicated trains had been discussed The possibilities that future shipments might occur in accordance with DOT regulations, which allowed regular train service, prompted the resolution.
May 5, 1987	City of Pittsburgh Public Hearing	Routing, NEPA, and general public concern with the TMI shipping campaign	Triggered by the April 11, 1987, Conrail derailment at Bloomfield, Pennsylvania, which resulted in evacuation of a large number of residents (derailment in the city of Pittsburgh, Pennsylvania, on a track used by TMI-2 trains) See Appendix G for documentation of this sizeable meeting.
March 22, 1988	Mayor's briefing, Washington, D.C.	Nuclear waste management, specifically TMI-2 shipping campaign	This meeting was arranged by Congressman Jack Buechner, Missouri, through DOE's Congressional Affairs Office for mayors, constituents, and special interest representatives of the St. Louis, Missouri, area The meeting was in a briefing/question/answer format.
April 11, 1988	Various persons from St. Louis and Columbia, Missouri	Improving communications	This meeting involved the EG&G Idaho spokesperson and a range of local officials and news media representatives See Appendix G for a report of the results

Table 3-15. (continued).

Date	Community	Issue	Result
May 5, 1988	Mayors meeting, Kirkwood, Missouri	Legality, licensing, cask testing and safety, other	A DOE team met with three St. Louis area mayors and members of Citizens Against Radioactive Transport to discuss the campaign. This was a follow-up meeting to the March 22, 1988, meeting in Washington, D.C. See Appendix G for a letter report of the meeting.

NEPA—National Environmental Policy Act.

Also in this timeframe, in the opinion of the shipping team, working relations with the States were improving. This may have been related to a better understanding of the campaign, the cumulative result of information transmittals, responsiveness to State requests to DOE, or other reasons. In any case, the States became more instrumental in resolving difficulties and addressing concerns in their areas of jurisdiction.

3.5.4 Governmental Investigations and Inquiries. Aside from a very large number of individual responses to senators, congressmen, governors, and other elected officials, there were several government-related investigations or inquiries that require description because of size or importance, and effort on the part of the shipping team to respond.

3.5.4.1 GAO Audit of 1986. In June and July of 1986, Congressman William L. Clay, Richard A. Gephardt, and Alan Wheat, all of Missouri, requested the GAO to report on DOE's program to ship damaged nuclear fuel from the TMI nuclear power plant near Harrisburg, Pennsylvania, to the INEL. In particular, the GAO was requested to report on:

- Reasons why the debris was being shipped to Idaho
- Safety standards used for the shipments
- Testing of the transport casks
- Criteria used to select the shipping route, because of concerns from the July 1986 rail accident in Miamisburg, Ohio, involving fire and hazardous cargo
- Emergency planning along the route.

The GAO report, *Shipping Damaged Fuel from Three-Mile Island to Idaho*, was published in August 1987 after an exhaustive study by the GAO.[65] The executive summary for this report is provided in Appendix L. There were no improprieties identified nor recommendations for changes to the shipping program.

3.5.4.2 FRA Investigation. An FRA report issued April 6, 1988, reported on an investigation of an incident of incorrect placarding of a railcar during the 14th shipment, which originated at TMI on February 7, 1988. The incident involved substitution of a covered hopper car at East St. Louis, Illinois, for one of the gondola cars on the train that originated at TMI-2 after a brake defect was identified. The covered hopper car, although loaded with lime, not a hazardous material, was placarded incorrectly as containing calcium carbide, a hazardous material. A number of DOT's hazardous material regulations were violated (see Appendix L for the text of the FRA report). The incident resulted in several FRA recommendations regarding conduct of operations by the railroads handling the TMI-2 shipments. The FRA investigation also included a reinspection of the condition of the tracks in the St. Louis, Missouri, area.

Because the FRA investigation is closely coupled to several other issues related to the St. Louis, Missouri, area, a discussion of those issues and corresponding adjustments is provided at this point. Resistance to the TMI-2 shipments had steadily increased in East St. Louis from the start of the campaign. Many letters to DOE had been transmitted from private parties, and from the Department of Public Safety for St. Louis, the Governor of Missouri, Senator Jack Danforth, Missouri, and Congressman Jack Buechner, Missouri. In addition to strong opposition to the trains passing through St. Louis, issues revolved around passage during rush hours stated as 6:30 to 9:30 a.m. and 3:30 to 6:30 p.m., claims of excessive train speeds (unverified), railroad safety, emergency preparedness, and so forth. The placarding incident was a much publicized event that resulted in several adjustments to operating procedures and other agreements, largely as a result of discussions/negotiations between Senator Danforth, Missouri, and Secretary of Energy Herrington. These procedural changes and agreements were as follows:

- The TMI-2 shipments would not resume until the FRA investigation was completed

- The TMI-2 train configuration would be consistent for the entire trip except for switching locomotives and the caboose from Conrail to UP [i.e., the buffer cars (gondolas loaded with ballast) would be dedicated with no switching in East St. Louis, Illinois]

- The rush-hour traffic periods would be avoided

- DOE would assign personnel to the train to monitor safety

- To minimize the number of shipments, all subsequent shipments would be consolidated to include three casks

- Railroad management personnel would accompany the train through St. Louis, Missouri, to monitor speeds

- DOE would conduct additional emergency response training in Missouri to clarify State, local, and Federal roles

- Inspections would be intensified in East St. Louis, Illinois

- DOT would conduct an independent study of the route selection.

While simple in concept, these changes were not easy to implement in practice. The Conrail schedule for initiating the TMI-2 shipments on Sunday mornings at TMI was based on traffic patterns on their rail lines (see Section 3.2.3, any day pickup discussions). As a company, Conrail was not receptive to considering alternate pickup times, because of their analysis of projected stops, safety, etc. Accordingly, a train had to leave TMI on schedule and avoid excessive delays along the way to travel St. Louis, Missouri, before the start of the morning rush hours. The concept of holding a train in a yard awaiting the end of the morning rush hours was notably undesirable. Consideration was given to use of a dedicated locomotive (from either Conrail or UP) to avoid the time required for switching between Conrail and UP, but was rejected. From the beginning of the campaign, the Conrail Avon Yard in Indianapolis was used for crew changes and inspections. Starting in April 1988, following the FRA report and recommendations, the agreements between Secretary Herrington and Senator Danforth, and considerable negotiations with the rail companies, the Avon Yard was also used as a locomotive and caboose switching point. The Conrail locomotive and caboose were removed from the TMI-2 train and replaced with a UP locomotive and caboose. The UP equipment was then operated by a Conrail crew to East St. Louis, Illinois. Prior to April 1988, this changeout had occurred in East St. Louis, Illinois. This changeout pattern eliminated the A&S Railroad buffer car switching operation, streamlined crew changeouts, and enhanced ability to meet the schedule to avoid travel during rush hours in St. Louis, Missouri. However, the agreements placed additional personnel in the cabooses, which at times offered only marginally acceptable living conditions.

3.5.4.3 DOT Route Analysis. As part of the agreements between Senator John C. Danforth of Missouri and Secretary of Energy John S. Herrington following the TMI-2 train car placarding incident discussed above, the Secretary of Energy requested DOT to conduct an independent assessment of the TMI-2 route in a letter to Secretary of Transportation James H. Burnley, dated April 29, 1988. The report was completed in November, 1989[66] (see Appendix L for the executive summary of the report). The report documents a comprehensive review of the processes used by DOE in route selection. DOT concluded that the route selected was a reasonable choice based on DOE's routing criteria.

3.5.5 Written Communications. In addition to the hundreds of responses in written form prepared during the TMI-2 campaign as previously identified, several other categories of written responses are worthy of mention, either because of size or importance. Generally, these responses fall in the areas of responses to critiques, Freedom of Information Act (FOIA) requests, or Congressional inquiries.

3.5.5.1 Critiques. A critique authored by Marvin Resnikoff of the Sierra Club Radioactive Waste Campaign entitled "Analysis of Model 125-B TMI Shipping Cask," dated July 8, 1986, was received by the TMI-2 Program just before the start of the shipping campaign. The critique centered on the cask thermal analysis and presented a series of allegations, which principally claimed that the Model 125-B cask to be used for transport of TMI-2 core debris, as designed and fabricated, may not withstand a hot and long duration fire resulting from a transportation accident. This four-page critique served to cause a number of inquiries to the program from outside parties who were unable to interpret the accuracies or inaccuracies of the allegations. Several months were required for the program to generate an approximately 40-page response to the allegations (included in Appendix L). The response also proved useful later when requests for related information were received from various parties.

3.5.5.2 Freedom-of-Information Act Requests. Response to requests for information under the FOIA required considerable effort on the part of the shipping team and responsible DOE FOIA Office personnel. Representative FOIA requests are tabulated in Table 3-16 by date, requestor, and the requested information (or a synopsis where the request was very long). These are not all-inclusive of requests to DOE nor do they include requests to others, such as the NRC.

3.5.5.3 Newspaper Articles. Newspaper articles about the TMI-2 shipments, and known to exist from receipt by the TMI-2 Program, are tabulated in Table 3-17 by city, State, newspaper, and number of articles. The total number of articles written is considerably more than the 81 articles tabulated here; also, this total does not include newsletters, journals, or articles in similar publications.

The newspaper articles were sometimes accurate portrayals of the campaign events, but often contained inaccuracies, bias, or flamboyant statements. Serious inaccuracies and accusations were addressed from time to time by the program spokesperson or members of the shipping team. All news media personnel were treated with respect and were provided information upon request. Some of the titles of the newspaper articles are informative as to conditioning of the reader; a few titles are listed below:

Radioactive Railroad

Nuke Shipment Study Faulty, Says Gephardt

Protesting Nuclear Waste Shipments

Radioactive Waste—Officials Say Trains Carrying It Can't Be Stopped

A Regulatory Sidetrack . . . and Nuclear Nervousness

Rail Probe Slows TMI Shipment

Senator Asks Safety Study of TMI Cargo

Timing of Nuclear Waste's Passage Here Assailed

Senator Asks Halt to Rail Shipments of TMI's Waste

Senator Complicates TMI Cleanup

Danforth Seeks Halt in TMI Shipments

Conflict Follows TMI Train

TMI Disaster Plan Lax, Experts Told

Danforth: Not Much Else to do About Nuclear Waste Shipments

Buechner Cites Rail Spills in TMI Testimony

Put a Tighter Rein on Nuclear Wastes

TMI Nuclear Freight Passes Many Homes, Federal Report Says

Nuclear Waste Train Sets Mayors on Edge

The Reaction is Mixed Along N-Waste Route

City on Radioactive Waste's Route

Opposition Mounts Toward TMI Core Shipments

Rail Radiation Threat to City

Controversy Forms Escort for TMI Waste

Forty Trains of N-Waste to Roll By

Auto Hit by Train From TMI

Transport of Radioactive Waste Becoming Political Hot Potato

U.S. Agency Faults Railroads in Metro East TMI Incident.

Table 3-16. Freedom of Information Act requests.

Date	Requestor	(Synopsis) Request
June 24, 1986	A. L. Wiman 4KMOV-TV St. Louis, Missouri	(Synopsis) Copy of any and all agency documents (records and information) relevant to and/or generated in connection with the disposition of the irradiated fuel, reactor internals, and related radioactive waste from TMI-2. (Essentially all documents inclusively related to TMI-2 shipping campaign decisions.)
July 28, 1986	Lindsay Audin, private citizen	Physical security plan and other information
November 19, 1986	Roger Pryor, Program Director, Coalition for the Environment	(Synopsis) Reports related to criticality during packaging, transporting, and/or storage of TMI-2 core debris; documents related to the Model 125-B cask safety analyses; letters from Nuclear Packaging to Transportation Certification Branch of NRC; Bill of Lading for a TMI-2 core debris shipment; and other reports.
May 5, 1987	City of Pittsburgh via Ashley C. Schannaver, Assistant City Solicitor	1. Proposals received from shippers, transporters, or common carriers regarding the transportation of the materials (from TMI-2) by rail or other mode of transportation. 2. Analyses of proposed routes and modes of transportation for the materials (from TMI-2), including alternatives (including any environmental assessments and/or environmental impact statements prepared for the shipment of the materials described), as well as records that indicate why said assessments or impact statements may not have been prepared. 3. Requests of DOE or its contractors or subcontractors for comments on the proposals and analyses described in items 1 and 2 from the public, government agencies, States and municipalities, shippers, transporters, common carriers, or others. 4. Comments, including letters, reports, and memoranda of phone calls and meetings, received in response to the requests described in item 3.

Table 3-16. (continued).

Date	Requestor	(Synopsis) Request
		5. Records embodying any decisions and/or approvals made by DOE, its contractors, and subcontractors, and other government agencies in regard to routes and modes of transportation for the materials (from TMI-2).
May 18, 1987	Shelley Nelkens, Director, NH Citizens versus Price-Anderson	Any and all information on the organisms found growing in the core of TMI-2, especially any material related to the removal and study of these organisms
June 19, 1987	R. Roger Pryor, St. Louis Program Director, Coalition for the Environment	1. The 1981 NRC-DOE Memorandum of Understanding that addresses the decision to transport the TMI core debris to Idaho Falls. 2. The report(s) describing the amount of hydrogen measured in each of the first six canisters tested as of May 1987 upon its arrival at the INEL—and the non-detectibility of any oxygen within. Also appreciate a brief description of the original location or zone within the reactor vessel from which each of the canister's contents was extracted. 3. Any documentary evidence which indicates that DOE has known since before 1985 that some of the uranium pellets had melted during the TMI-2 accident. 4. A list of the GEND reports on the TMI-2 accident that have been prepared so far. 5. A report on the impact upon instruments and electrical equipment of radiation and the loss of coolant during the TMI-2 accident.

Table 3-17. Number of newspaper articles published about TMI-2 shipments.

City, State	Newspaper	Number of articles
St. Louis, Missouri	Post Dispatch	20
Idaho Falls, Idaho	Post Register	22
Harrisburg, Pennsylvania	Patriot-News/The Patriot	8
Johnstown, Pennsylvania	Johnstown Tribune-Democrat	5
St. Louis, Missouri	Webster-Kirkwood Times	3
Kansas City, Missouri	Times	1
Twin Falls, Idaho	Times News	2
Sikeston, Missouri	Standard	1
Atwood, Kansas	Citizen Patriot	1
Pittsburgh, Pennsylvania	Post Gazette	5
Pocatello, Idaho	The Idaho State Journal	2
Lancaster, Pennsylvania	New Era	2
St. Louis, Missouri	West County Journal	1
Boise, Idaho	The Idaho Business Review	1
Pittsburgh, Pennsylvania	Press	3
Kansas City, Missouri	Kansas City Star	1
Omaha, Nebraska	Omaha World Herald	1
New York, New York	The New York Times	1
Boise, Idaho	The Idaho Statesman	1
Total		81

4. LESSONS LEARNED FROM THE TMI-2 CORE DEBRIS SHIPPING CAMPAIGN

The authors use this section to collect the lessons learned from the TMI-2 core debris shipping campaign. The meaning of some of the "lessons" might be different depending on a reader's viewpoint on the transport of nuclear materials. We believe that such transport operations are required, and will occur, in the future. The lessons below are directed at assisting those management and engineering personnel who will perform similar future activities.

4.1 Working with Elected Officials

DOE, in conjunction with other Federal agencies, was implementing national policy, affirmed by two U.S. presidents, in R&D activities and support of the cleanup of the TMI-2 accident. Those DOE activities, including acceptance and transport of the TMI-2 core debris, were frequently reviewed by Congressional committees through the process of testimony on technical progress and DOE budget authorizations. Accordingly, there was approval at the highest levels of government for the transport activity. Senators and congressmen, who in some cases were associated with Congressional committees, responded to personal or constituent concerns in calling for investigations, or in proposing actions that would have effectively curtailed DOE from completing its assigned task. On the one hand, a national politician could have DOE investigated for technical decisions that could be presented as possibly delaying the important and necessary job of defueling the reactor, and removing the core debris from the TMI-2 facility. While on the other hand, the same politician could seek to overturn DOE's technical decisions on cask decisions or route selection, a vital part of accomplishing the removal action. The lesson is that elected officials often have very different simultaneous agendas that may or may not support technical programmatic positions and decisions. Specifically:

- Elected officials will be sensitive to the concerns of their constituency, even if, to technically oriented professionals, the concerns are invalid.
- The type of concern an elected official will support will vary greatly depending on government organization. A congressman may be concerned with DOE policy; a mayor is more likely to focus on specific issues of public safety. Since the concerns of a mayor are more concrete, a specific and substantial answer is better received and usable.
- A good deal of the interaction with Congress is through support staff personnel, wherein filtering of communications can be a problem. The interactions may be with individuals of unknown persuasion on the transport of nuclear waste.

4.2 Changes in Personnel

The TMI-2 shipping campaign lasted most of four years from the first to final shipment. During that period, there were at least two major elections, with many changes among elected officials at both the highest to lowest levels. Also, there were many changes in personnel at the appointed levels due to changing of jobs, promotions, and so forth. A major lesson learned by the TMI-2 core shipping team is that very close working relations with local and State personnel are vital to resolving issues and concerns of the transport action. At the start of the campaign, the program believed they were communicating with all the right parties, in accordance with established prenotification policies, only to discover that the assumption was incorrect. The program had contacted all the affected States before the campaign and met with three of the States for detailed discussions. The program now believes that a meeting with every State could have avoided events such as when the Governor of Nebraska stopped the first shipment at the State line. Elections and departures mean changes, and communication with new individuals is needed along with personal contact and possibly retransmitting of previous communications. The TMI-2 shipping team learned to track changes in personnel at all levels quite carefully.

4.3 Public Relations Plan

The TMI-2 Program did a credible job in preparing a public relations plan before the campaign started. The program accepted and enhanced all established public relations procedures, prepared and distributed program briefs and videos, cohosted a media day, made public announcements, performed prenotification activities, and met with some State and public officials. However, the effort was too reactive. Members of the public opposed to nuclear transport actions can be highly effective in communications. Accusations can be generated based on faulty or inaccurate observations and forwarded to a number of public officials who in turn redirect the issue or accusation in many forms to DOE's attention. There is seldom any retraction of incorrect statements. While DOE's response is being prepared, the original document is creating confusion. A good example of this was the Sierra Club's allegations at the start of the TMI-2 campaign. The allegations created endless issues for the public and were not fully answered for some time by the program. One solution to this is a more proactive public relations plan up front, which allows program representatives to go and meet the people that have the concerns (town meetings, etc.). There were several important concepts and techniques instrumental in the degree of success achieved for the TMI-2 campaign by the public relations effort. Persons planning future campaigns to transport radioactive materials should consider the following when developing and implementing public relations plans:

- Develop and maintain good communications and relationships with State and local officials

- Provide briefings for State and local officials, and attend public meetings when requested

- Designate a single-point contact as spokesperson to public and news media inquiries

- Respond in a factual and timely manner to requests for information

- Prepare informational materials for distribution to the community.

4.4 Interfacing Equipment with Facilities

Equipment interfaces, both at the INEL and TMI-2, took a lot of planning, teamwork, and honest and open communication. The integrated test of all cask handling and cask loading equipment that was performed at the Maintenance and Support Facility of the Fast Flux Test Facility of the Hanford Engineering Development Laboratory was very valuable for confirming cask-to-handling equipment fitup, training of GPU Nuclear personnel, development of procedures, and generally proving system performance. The test resulted in a much smoother installation and startup of equipment at the TMI-2 facility, and something similar to this test is recommended for future checkout of transport package, handling, and loading equipment (see Section 2.6.4 for more discussion).

4.5 Dry Loading Equipment

The use of dry loading equipment at a commercial nuclear power plant provides an important lesson in dose reduction and improving operational efficiency. In comparison to wet loading of a cask, there is no need for hands-on decontamination of the exterior cask surfaces after removal from the water. With dose rates allowed to reach 200 mrem/hr at a cask's surface, the potential savings in dose is significant. In addition, the dry loading equipment is likely to be cost-effective for campaigns requiring many shipments. Many workhours are saved per cask loading by eliminating underwater handling of a cask and its lid, draining, and external surface decontamination. The reduced hours to prepare a shipment increase operational efficiency and lower operating costs. The cost savings offset the original expense of the dry loading equipment. One piece of dry loading equipment used at TMI-2 also provides a lesson for some power plants with cranes with insufficient capacity to lift large and heavy casks. The hydraulic cylinders used to upright and lower the 125-B cask for loading at TMI-2 are a practical and safe method for allowing use of a cask too heavy for an existing overhead crane.

4.6 Distribution of Transportation Correspondence

Shortly after the start of the TMI-2 transport campaign, it became obvious that public correspondence would be extensive. DOE-NE issued a letter that provided instructions related to distribution of correspondence, so that the involved DOE organizations could be informed and consistent in response. Nevertheless, it was noted that the instructions were not always implemented because of the logistics of so many letters, and correspondence did not always reach appropriate personnel. This was particularly noted with final responses to FOIAs. Future workers of transport actions may benefit from an enhanced correspondence distribution policy (e.g., use of an electronic mail system).

A similar problem was the difficulty of obtaining timely, on-the-scene information (of meetings and actions being taken in communities for example) from either Washington, D.C., or Idaho. By the time information was being received, or a response prepared, the situation was already blown out of proportion. Regardless of best efforts, or for that matter, timeliness of response, some of this will occur and some things must simply be considered uncontrollable.

4.7 Rail Carrier Negotiations

Negotiations with the rail carriers can be characterized as cooperative, but sometimes very difficult. Rail companies have a long history of established operations and procedures and clearly know the railroad business better than outside parties. This contrasts to a belief among some public, government officials, and others that railroad company procedures can be changed by the imposition of a programmatic policy or directive. Most often, such is not the case. When a railroad is operating in accordance with regulations governing transport of radioactive materials (U.S. DOT, Interstate Commerce Commission, and other requirements, as applicable), then a program will encounter difficulty in trying to impose change. If a program, such as the campaign described in this report, sets out to dictate procedures for rail carriers to use, the same program should be prepared for the rail company to deny service. Nuclear material transport is generally not much more than a minor source of income to the rail company, but is a major irritant.

Other lessons from working with the rail carriers were as follows:

- Major differences will exist between rail companies pertaining to their approaches and procedures for transporting nuclear materials (and obtaining uniformity between companies would be very difficult)

- A good programmatic approach in areas that do not heavily impact programmatic needs is to rely on the railroad's expertise and to beware of intruding into their area of expertise

- Negotiations can be successful in areas of common concern such as resolving public issues; in areas of programmatic need; in areas where the program requires respect as the customer; and in pricing of services

- Caution should be exercised regarding imposing constraints on the rail companies that could lead to unsafe conditions (such as route usage).

EG&G Idaho's traffic manager had a good understanding of, and working relationship with, the railroads, which assisted the program greatly.

4.8 Chase Vehicles

With regard to lessons learned in transport operations, there is a serious potential for accidents by State personnel in escort or chase vehicles trying to maintain close proximity to a train, even one travelling at 30 mph. The problem is roadways that do not parallel rail lines and the sometimes very high speeds required for escort vehicles to maintain contact. The need for such chases should be carefully considered in the future since the risk of accidents involving the chase vehicles is surely increased by such policies.

4.9 Cask Inspection Risks

Another lesson learned from the TMI-2 shipments was that some inspection procedures can result in increased risk. Inspections of the rail cask both by the train personnel each time a train stopped and by repeated State inspections resulted in small doses of radiation to the involved personnel. Whereas the dose rates external to the TMI-2 cask were much less than allowable DOT limits, dose rates for future spent fuel shipments can be expected to be higher. The policy of frequent and repeated inspections will lead to small but seemingly unnecessary doses to personnel that translate into increased risk for incident-free radiological consequences to those exposed individuals. There is a potential that railroad personnel should start monitoring exposures with film badges. The need for such frequent inspections, or the benefit of equipment to perform the checks on the status of the cask remotely without personnel doses should be considered for future large campaigns. Additionally, an observation was that one of the biggest risks in the inspections at sidings was getting hit by another train.

4.10 Impact of Unrelated Events

Another lesson of consequence that future shippers should prepare for is that events unrelated to the shipping activity can have a significant influence on the activity. The text includes several examples: the hazardous material train wreck in Pittsburgh and the bridge derailment near St. Louis. Even the Space Shuttle Challenger disaster had an effect, raising concerns about the behavior of O-ring seals at low temperatures.

4.11 Licensing, Teamwork, Problem Prevention, and Attention to QA

Perhaps one of the best keys to success for all activities related to transport of the TMI-2 core debris was teamwork, attention to detail, emphasis on prevention of and/or early detection of problems, and stringent QA aimed at preventing problems. These policies were practiced throughout all technical activities—from design of the cask system to storage of canisters at the INEL. Many examples are cited in the text. The whole experience of the cask licensing process is one example: proper use of testing, "in process" discussions with the regulatory agency, on-the-spot QA and engineering oversight, and so forth.

4.12 TRANSCOM System Test

During the TMI-2 core debris shipping campaign, DOE was developing a transportation communication system using satellite tracking with the acronym of TRANSCOM. TRANSCOM is one component of DOE's Emergency Preparedness Planning and Training Program.[67] TRANSCOM is expected to be used to help ensure safety in DOE transport actions such as the proposed shipments of transuranic waste from DOE facilities to the Waste Isolation Pilot Plant in New Mexico.

DOE had been testing TRANSCOM with truck transport on highways and desired similar tests with rail systems. In late 1989, discussions began with the TMI-2 Program for placing the TRANSCOM equipment on a TMI-2 core debris rail shipment. The program was not in favor of a test on a loaded shipment because the campaign was nearing completion and the complications of change was not desirable. However, there was no objection to the equipment being placed on an empty cask return shipment.

The test was arranged by ORNL and coordinated with EG&G Idaho and the railroads. The TRANSCOM satellite tracking system was installed on a gondola car and the power system was installed in a caboose. The cars were mated with the empty cask return shipment from the 45th cask load by UP in Pocatello, Idaho. As with other empty cask shipments from the INEL to TMI, the cars were placed on regular freight.

There may be several lessons from this activity. First, installing the equipment on the train cars was accomplished without difficulty. However, the railroads separated the cars midway through the shipment causing loss of credibility to the rail company. Otherwise, as reported to EG&G Idaho, ORNL received good information on system performance.

4.13 Lessons From Related Programmatic Activities

The related activities of defueling tooling, defueling the TMI-2 reactor, core examination, and the Accident Evaluation Program have a host of lessons learned that are much too extensive for discussion herein. The reader is apprised that much of the TMI-2 R&D effort was discussed at a TMI-2 topical meeting as part of the American Nuclear Society and European Nuclear Society International Conference, October 30 through November 4, 1988, in Washington, D.C. The presentations of that symposium and the vast array of lessons learned are largely contained in a set of American Nuclear Society, Inc., publications entitled "The TMI-2 Accident Materials Behavior and Plant Recovery Technology," *Nuclear Technology, Volume 87*, No. 1, August 1989; "Health Physics and Environmental Releases," *Nuclear Technology, Volume 87*, No. 2, October 1989; "Remote Technology and Engineering," *Nuclear Technology, Volume 87*, No. 3, November 1989; and "TMI-2: Decontamination and Waste Management," *Nuclear Technology, Volume 87*, No. 4, December 1989.

Other sources of the lessons learned from the TMI-2 accident are *TMI-2: Lessons Learned of the U.S. Department of Energy*, DOE/ID-10276, March 1990; and *The Cleanup of Three-Mile Island Unit 2, A Technical History: 1979 to 1990*, EPRI NP-6931, September 1990. Lessons and information are also contained in Table 4-1, which provides a listing of papers related to the TMI-2 core debris shipping campaign. Other papers have been included in the references, but the references and Table 4-1, taken together, do not necessarily represent all papers published on the campaign.

4.14 Workshops

There were two workshops that explored the lessons learned from the TMI-2 shipping campaign. A workshop held at TMI, September 15 and 16, 1987, was devoted entirely to the TMI campaign and included attendees from a number of DOE field offices with large transport operations pending, such as the Waste Isolation Pilot Plant in New Mexico.[68] The reference contains the presentation materials from this workshop providing a comprehensive overview of the TMI shipping campaign. An OCRWM-sponsored Cask Operations Workshop in Albuquerque, New Mexico, August 1–3, 1990, included presentations of the lessons from the TMI-2 campaign.

Table 4-1. Listing of published presentationss concerning TMI-2 core debris shipments.

G. J. Quinn and H. M. Burton, "TMI-2 Spent Fuel Shipping," *Waste Management '85*, March 24–28, 1985.

F. C. Fogarty, "Handling Severely Damaged Fuel: Technical and Regulatory Aspects of Packaging and Shipping Failed Fuel and Fuel Debris," EGG-M-26085, *ANS Executive Level Topical Meeting, TMI-2: A Learning Experience*, October 15, 1985.

R. C. Schmitt and G. J. Quinn, "Preparations to Ship the Damaged TMI-2 Reactor Core," EGG-M-17985, *ANS Winter Meeting, San Francisco, California*, November 11–14, 1985.

H. W. Reno, R. C. Schmitt, G. J. Quinn, A. L. Ayers, Jr., B. J. Lilburn, Jr., and D. L. Uhl, "Preparations to Load, Transport, Receive, and Store the Damaged TMI-2 Reactor Core," *Waste Management '86*, March 3–6, 1986.

G. J. Quinn, et al., "Transporting Fuel Debris from TMI-2 to INEL," EGG-M-T0286, *IAEA International Symposium on the Packaging and Transport of Radioactive Materials (PATRAM 86)*, June 1986.

H. W. Reno and R. C. Schmitt, "TMI-2 Reactor Fuel Removal, Loading, Transport, and Storage," *ANS International Meeting Low-, Intermediate-, and High-Level Management and D&D Niagra Falls, New York, September 14–18, 1986*, September 1986.

R. C. Schmitt and H. W. Reno, "Preparations to Transport, Receive and Store the Damaged TMI-2 Core: Lessons Learned," EGG-M-28486, *Second International Conference on Radioactive Waste Management, Canadian Nuclear Society, Winnipeg, Canada, September 7–11, 1986*, September 1986.

W. W. Bixby, W. R. Young, P. J. Grant, "TMI-2: Unique Waste Management Technology," *Waste Management '87*, March 1-5, 1987.

R. C. Schmitt, H. W. Reno, W. R. Young, and J. P. Hamric, "Transporting TMI-2 Core Debris to INEL: Public Safety and Public Response," EGG-M-15087, *1987 International Waste Management Conference Kowloon, Hong Kong*, November 30 – December 5, 1987.

M. J. Tyacke, L. J. Ball, A. L. Ayers, Jr., G. R. Hayes, and A. A. Anselmo, "Transport Package Maintenance Requirements and Operations," EGG-M-88178, *ANS Topical Meeting on TMI-2 Accident: Materials Behavior and Plant Recovery Technology, Washington, D.C.*, October 31 – November 4, 1988.

J. O. Henrie, "The Effects of Hydrogen Generation on Radioactive Waste Handling Technology," *Nuclear Technology, Volume 87*, Number 4, December 1989.

G. R. Hayes and J. F. Marsden, "Quality Assurance in the Removal and Transport of the TMI-2 Core," *Nuclear Technology*, Volume 87, Number 4, December 1989.

G. R. Hayes, "QA in the Design and Fabrication of the TMI-2 Rail Cask," American Society for Quality Control, *Fifteenth Annual National Energy Division Conference*, October 23-26, 1988.

C. M. Abbate and J. W. Craig, "NRC Inspection of Transportation Casks," *Nuclear Technology, Volume 87*, Number 4, December 1989.

Table 4-1. (continued).

T. A. Smith and A. A. Anselmo, "Working with the States to Transport TMI-2 Core Debris," *Waste Management '89, Tucson, Arizona*, February 26 – March 2, 1989.

R. C. Schmitt and L. H. Harmon, "Transporting Spent and Damaged Fuel in the United States: Recent Experience and Lessons Learned Related to the Evolving Transportation Policy of the U.S. Department of Energy," EGG-M-89376, *1989 Joint International Waste Management Conference, Kyoto, Japan*, October 22–28, 1989.

H. W. Reno, R. C. Schmitt, and W. C. Lattin, "Transporting Spent and Damaged Fuel in the United States: Recent Experience and Lessons Learned Related to the Evolving Transportation Policy of the U.S. Department of Energy," EGG-M-88416, *PATRAM '89, Washington, D.C.*, June 11–26, 1989.

J. W. McConnell, Jr., W. T. Shurtliff, R. J. Lynch, K. M. Croft, L. J. Whitmill, and S. M. Allen, "TMI-2 Fuel Canister and Core Sample Handling Equipment Used in INEL Hot Cells," EGG-M-28686, *Waste Management '87*, March 1–5, 1987.

5. POST-CAMPAIGN ACTIVITIES

After the last loaded cask had been unloaded at TAN, the leased cask, number 003-IT, was sent back to TMI. The DOE-owned casks, numbers 001 and 002, were decontaminated and returned to CFA. The casks were loaded onto the railcars and moved to a side spur of the railroad track for monitoring and storage. All of the cask handling equipment used at CFA and TAN were inventoried. The large horizontal lift fixture, vertical lift fixture, and load test fixture were placed on the cars with the casks as is, while the smaller equipment was placed on the cars in plywood boxes with the lids sealed, and an inventory list attached.

Six boxes of spare parts for the NuPac 125-B casks were received from TMI-2. An inventory was taken and the boxes were resealed and painted. The boxes were also loaded onto the railcars with the other cask handling equipment.

Commencing January 15, 1992, responsibility for the NuPac 125-B rail casks transferred from DOE-NE to DOE-OCRWM. OCRWM performed a study that determined that future uses for the casks may develop in their areas of responsibilities related to transport actions to the proposed national high-level waste repository. The NRC fees that were incurred in relicensing the casks in 1991 were shared equally between DOE-NE and OCRWM. The casks are in a minimum maintenance program, performed by EG&G Idaho, under the cognizance of the DOE-ID OCRWM Branch.

The canister handling equipment was transferred from the TMI-2 Program to TAN Hot Shop Operations for future handling of the canisters. Other equipment used in the cask and canister handling operations not unique for those operations were either disposed of, excessed, or given to other projects. The storage module poison plates and lock mechanism, and the vent tube on each canister continue to be periodically checked.

Some of the follow-on activities have included responding to inquiries, that is, FOIA requests; production of documents in response to State of Idaho litigation actions; requests for general information about the shipments and storage activities; studies evaluating the removal of the core debris from the Hot Shop storage pool and placing it in dry storage on a pad; and core accountability studies. These activities are discussed as follows:

- **FOIA** — There have been several iterations on a FOIA request by David DeKok, formerly a newspaper reporter for the *Patriot-News* in Harrisburg, who proposed to write a definitive history of the TMI-2 accident and its impact on the world. A substantial number of documents were produced and transmitted related to transportation of the TMI-2 core. Other facets of Mr. DeKok's requests, which applied to vast amounts of materials related to DOE's involvement in the TMI-2 effort during and after the accident, were granted in part and denied in part by DOE FOIA officers. The TMI-2 Program was involved in producing documents where such were authorized by DOE. A title listing of nearly 19,000 documents in the TMI-2 Documentation Data Base has been sent to Mr. DeKok. The exact status of Mr. DeKok's present efforts and the FOIA is not known to the authors.

- **State of Idaho issues** — The State of Idaho in 1991 and 1992 has assumed a substantially negative attitude to receipt of further shipments of some radioactive waste at the INEL, until Federal actions to open the Waste Isolation Pilot Plant and to show progress for a high-level waste repository are achieved. Spent fuel is one category of waste that the State is notably opposed to accepting in Idaho. The result has been some litigation in the courts involving DOE and the State. As part of that litigation, the State requested copies of documents for all spent fuel (and other waste) at the INEL. TMI-2 was included. A full reproduction of all documents would have numbered many thousands of documents. Certain representative documents were reproduced for State review in 1992; that review is ongoing at this time.

- **General information** — Several requests from outside parties, including engineers, a congressman, the State, and private parties have been received resulting in a reproduction of information, on the status of core debris storage, shipping casks, and similar subjects. These requests, while occupying a share of the remaining effort on TMI-2 programmatic tasks, are not discussed further in this report.

- **Transferring TMI-2 core debris to dry storage** — TMI-2 programmatic funding was made available in 1989 for preliminary design of a dry cask storage system for storing the TMI-2 core debris canisters. Conceptually, the canisters would be removed from the TAN-607 Hot Shop pool, passed through a drying system to remove water, and placed in a dry cask storage system designed specifically for storing the canisters. There are several reasons for this potential action: (a) the canisters were designed for a 30-year in-pool storage design life (which was based on reasonable assumptions for opening of a national high-level waste repository), (b) the national high-level waste repository is experiencing significant delays and there are indications that the TMI-2 core debris might not be placed in the first repository (but TMI-2 core debris still remains on the list for that repository), (c) the DOE mission, strategy, and objectives are in a state of rapid evolution, particularly as it relates to matters of environment, safety, and health, (d) the TAN Hot Shop mission, along with continued operation of that facility, is under scrutiny, (e) placement of the TMI-2 core debris into a dry storage system is considered to be a step towards enhanced safety, and (f) there are views that such an action could result in large cost savings over maintaining the Hot Shop as an operating facility to store the core debris. The action to implement dry storage of the TMI-2 core debris is a line-item construction project in the early stages of implementation. There is no departure from the DOE intent to place the TMI-2 core debris in a national high-level waste repository at the earliest feasible time.

- **Core accountability studies** — Each shipment of special nuclear material (SNM) was accompanied by a Nuclear Material Transaction Report (DOE/NRC Form 741), which recorded the net weight of the contents of each canister and a best available physical description of the contents. A statement that quantification of the amount of SNM in each canister was not possible also accompanied each shipment as an annotation on the DOE/NRC Form 741. Since the canister contents were a mixture of SNM, other core debris, and structural materials, there was no feasible method at TMI-2 to determine the exact content of fuel in each canister. Therefore, SNM accountability for TMI-2 and the subsequent estimated quantity of record of fuel shipped to the INEL will be based on the total measured SNM remaining in the plant after defueling was complete. A final plant inventory of residual SNM will be reported on the DOE/NRC Material Balance Report (DOE/NRC Form 742).

The TMI-2 SNM Accountability Plan was initially issued in April 1987. The purpose of the SNM Accountability Plan was to define the method and sequence of SNM accountability, the Quality Assurance Program incorporated in the SNM Accountability Program, the areas, systems, and components that would undergo formal SNM measurement, and those that would not require SNM assessment. As defined in the plan, the post-defueling survey was the process by which the entire TMI-2 plant was surveyed to determine the presence and quantity of SNM in each applicable area. The accomplishment of the required SNM measurements and associated engineering analyses, and a determination of the estimate of record of the total quantity of residual fuel at TMI-2 constitute completion of the post-defueling survey program.

The comprehensive and systematic SNM accounting of all residual fuel in the TMI-2 facility is nearly complete; a final accounting of the residual fuel in the TMI-2 reactor vessel was completed by year end 1992. The results of each completed survey of an SNM area, system, or component were detailed in separate Post-Defueling Survey Reports (PDSRs). When the final PDSR has been completed (i.e., the reactor vessel PDSR), the results will be compiled to form the basis for the final SNM accounting for TMI-2. GPU Nuclear and DOE will then agree on the estimated quantity of record of fuel shipped to the INEL for take-title purposes and future disposal actions.

EG&G Idaho, on behalf of DOE, has been monitoring the GPU Nuclear efforts to reach accountability finalization, and in 1990, performed a study of SNM on a canister-to-canister basis. This study will be finalized when the GPU Nuclear and DOE agreement is complete.

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Appendix A

GEND Coordination Agreement, TMI–2 Information and Examination Program

COORDINATION AGREEMENT

TMI UNIT 2 INFORMATION AND EXAMINATION PROGRAM

1. INTRODUCTION

The TMI Unit 2 accident of March 28, 1979, was and is of great concern to the electric power industry, its customers, regulatory and other government agencies and the country as a whole. While the accident resulted in only limited radiation exposure to the population surrounding the power plant, the plant itself suffered extensive damage with high radiation contamination within the nuclear and other supporting systems and facilities. TMI Unit 2 currently presents opportunities to provide information for the enhancement of nuclear power plant safety and reliability of generic benefit to nuclear power technology. Four organizations, the Department of Energy (DOE), the Electric Power Research Institute (EPRI), the General Public Utilities Company (GPU), and the Nuclear Regulatory Commission (NRC), are interested in assuring that the research outlined by this agreement is effective in obtaining information during the course of the TMI-2 program. This coordination agreement identifies the broad areas of common research interests, and objectives to which the signatories subscribe, and lays out in broad terms methods by which the signatories have agreed to interact in an effort to achieve these objectives consistent with the other obligations of the signatories. Each signatory will implement its own individual programs in accordance with its own charters, authorizations and obligations, and nothing in this agreement is intended to commit a signatory to any particular program or activity. For its part, the GPU Company has a strong interest in protecting the health and safety of the public and the environment and in the return to safe commercial service of TMI Unit 2. It is recognized that the NRC will carry out its responsibility of assuring the adequate protection of health and safety of the public and the environment, regardless of whether the plant is ultimately returned to service.

2. OBJECTIVES

The TMI Unit 2 accident represented one of the most severe integral tests of nuclear plant safety philosophy and safety systems ever encountered in a commercial light water reactor. The extent of damage to the reactor core and the subsequent release of fission products to the primary system, containment, and elsewhere is the most extensive experienced in any known light water reactor power system.

The environmental conditions within containment and the reactor system pose one of the most technically challenging decontamination and radioactive waste management situations ever encountered. These circumstances represent opportunities for state of the art advancement not available through normal research, development, and test programs. Thus, it is our common objective that:

significant applicable information stemming from the TMI Unit 2 accident be obtained and made available for the general improvement of light water reactor plant safety, reliability, regulation, and operation.

unique data and experience at TMI Unit 2 that will be obtained during the plant decontamination and assessment of status be integrated into ongoing government, EPRI, and GPU research and development programs as may be beneficial. This information will be made generally available to others engaged in the design, construction, operation and maintenance of nuclear power plants.

information and experience of value be obtained during GPU's planned program.

The signatories believe that the stated objectives above should be pursued to the benefit of the country and are in the best interest of the Nation. To this end, most effective use should be made of the available resources of government and industry.

3. COMMON INTERESTS

Major areas of common interests are, and work is expected to be undertaken in the following:

(a) The development and reporting of information on the performance of instrumentation, electrical and mechanical equipment within the reactor containment and auxiliary buildings during and after the accident. This effort will encompass work on plant systems and components whose performance is of importance to general generic improvements in light water reactor safety and reliability. Information which could lead to improvements in component and system designs and standards and plant operability, especially under abnormal conditions will be included.

(b) The development of information on fission product behavior, transport and deposition, particularly as this may contribute to a better understanding of nuclear plant accident scenarios.

(c) The development of information, including information needed for regulation and operation, and the development and testing of new technology of potential industry wide application in the fields of

- plant, system and equipment decontamination
- radioactive waste processing and disposal methods and systems
- post-accident pressure vessel and other primary coolant system pressure boundary testing and qualification technology
- removal, packaging, transportation, storage and disposal of damaged nuclear fuel.

(d) The development and reporting of information on the nature and extent of physical damage to surfaces, structural components and equipment within the reactor containment and auxiliary buildings as a result of the accident.

(e) The establishment and effective utilization of a common data bank for all information gathered under this agreement.

(f) The development and reporting of information on the nature and extent of core damage, with the objective of understanding the chemical, metallurgical and physical behavior of fuel, clad, core components, and related reactor internals during and after the accident.

Recognizing that other areas of common interest may arise, that the possibility exists for discovering conditions not previously anticipated, or of new questions arising at some future time not presently being considered, the signatories agree that an archival system be established under which specimens of hardware or other samples may be stored off-site for possible future examination and testing.

4. JOINT COORDINATING GROUP

To provide a forum for effectively reconciling, where necessary, the various activities which may be undertaken in association with TMI recovery, a Joint Coordinating Group will be formed to which each signatory will appoint one senior representative. The group will act to provide an integrated overview of the R&D information and data gathering activities associated with TMI, to provide a means for each signatory to assess the priority of the expected large numbers of peripheral data and technology tasks, and to provide a means for the review and coordination of activities under this agreement. The Joint Coordinating Group will function to permit the fullest necessary management interaction of the parties. It will serve as one means to identify facility, equipment, personnel and financial resources for the accomplishment of common goals.

The Joint Coordinating Group will meet periodically (initially about once every two months) with responsibility for arranging each meeting alternating between the EPRI and the DOE representatives.

The Coordinating Group will form such subgroups or interact with such other parties as to facilitate common interests herein identified.

5. TECHNICAL WORKING GROUP

To assist the Joint Coordinating Group, the signatories agree to establish a Technical Working Group (TWG) whose functions are:

(a) to define, through individual contributions of the members, the technical work to be done and prepare plans

(b) to provide, through individual contributions of the members, detailed technical scope of work for specific tasks to be performed under the plan, and

(c) to provide a mechanism for feedback of results of each individual program, and a mechanism for individual members to identify any necessary changes and additions.

The TWG shall consist of technical experts representing each signatory. Three members shall represent each signatory but the composition may be changed to meet specific needs or altered conditions. The TWG shall meet periodically as needed and the meetings shall be arranged by DOE and EPRI representatives. The contributions of each representative to the TWG meeting shall be compiled and made available to the signatory organizations and the Joint Coordinating Group.

6. TECHNICAL INTEGRATION OFFICE

Technical Integration Office (TIO) will be established with functions as noted below. Since some of these functions are expected to involve on-site work, the parties agree to the following understandings regarding such on-site activities:

(a) All work within the reactor and auxiliary buildings will be arranged for, controlled, and executed by GPU or its subsidiaries and its contractors.

(b) GPU will make office space available, on a reimbursable basis, within or proximate to the site boundary, for the Technical Integration Office.

The functions of the Technical Integration Office shall include:

(1) The TIO shall be the interface between GPU and its contractors on the one hand, and the Joint Coordinating Group and its representatives on the other, for all matters related to work carried on pursuant to this agreement. This shall in no way be interpreted to extend to the normal requirements for information required for licensing or inspection and enforcement activities of the NRC, where existing channels shall continue to be used as appropriate.

(2) Pursuant to paragraph (a) above, the TIO shall assist in identifying the schedule of specific activities to be conducted on-site pursuant to this agreement, arranging for the carrying out of these activities,

the monitoring of these activities, and the reporting of data, selection and shipment of samples, etc.

(3) Review, in coordination with individual members of the TWG and GPU, proposed procedures related to activities conducted pursuant to this agreement so as to assure high likelihood of success of task objectives.

(4) For all activities, whether on-site or off-site, actually carried out pursuant to this agreement, provide for the systematic collection and collation of information obtained so that such information may be freely accessible to any person. To this end, the TIO will maintain liaison with the individual members of the TWG to define data to be collected, report format, and reporting schedule.

(5) Work performed pursuant to this agreement which is sponsored by the Government shall be contracted for by the TIO.

(6) Work performed pursuant to this agreement which is sponsored by EPRI shall be contracted for by appropriate means and the TIO shall be fully cognizant of the contractual arrangements so that it can perform its other integration, scheduling, interface, and information collection functions listed above.

(7) The TIO shall establish, and maintain, a system for controlling changes to the work scope that may arise from time to time. This system shall be approved by the DOE.

The TIO will be established, manned and funded by DOE. Other Government representatives may be attached to the TIO to assist in administering the functions of the TIO, including technical oversight of specific tasks conducted pursuant to this agreement.

7. STATEMENT OF LIMITATIONS

Each party to this coordination agreement will implement its own individual programs. Further, nothing contained in this document shall be construed to impose upon any party hereto liability for injury to persons or property arising in the course of the activities under this coordination agreement nor is anything intended to act to relieve or compromise the responsibilities of the General Public Utilities Company or its subsidiaries under their licenses from Government agencies. Nothing is intended to affect, modify or to act to change the internal management, structure or responsibilities of each of the participating groups individually.

Signed:

Robert L. Ferguson 26 March 1980
DOE

M. Levenson 26 March 1980
EPRI

G K Hovey for R C Arnold 26 March, 1980
GPU

Robert Budnitz 26 March 1980
NRC

Appendix B

Appendix B.1

Memorandum from James B. Edwards to the President of the United States, "Resolution of Remaining Civilian Nuclear Program Policy and Budget Issues for FY 1982," March 2, 1981

Appendix B.2

Memorandum from the President of the United States, to the Secretary of Energy, "Decisions on Department of Energy Budget Appeal," March 20, 1981

Appendix B.3

White House Policy Statement from Edwin Meese, III, Counselor to the President, to the Honorable Richard L. Thornburgh, Governor of the Commonwealth of Pennsylvania, October 19, 1981

Appendix B.4

U.S. Department of Energy, U.S. Nuclear Regulatory Commission, "Revised Memorandum of Understanding Between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy Concerning the Removal and Disposition of Solid Nuclear Waste from Cleanup of the Three-Mile Island Unit 2 Nuclear Plant," March 15, 1982

Appendix B.5

Agreement in Principle (between DOE and GPU Nuclear) for Acquisition of the Damaged TMI-2 Reactor Core by DOE March 19, 1992

Appendix B.1

Memorandum from James B. Edwards to the President of the United States, "Resolution of Remaining Civilian Nuclear Program Policy and Budget Issues for FY 1982," March 2, 1981

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

MEMORANDUM FOR: THE PRESIDENT

MARCH 2, 1981

FROM: James B. Edwards

SUBJECT: Resolution of Remaining Civilian Nuclear Program Policy and Budget Issues for FY 1982

The purpose of this memorandum is to inform you of the material on nuclear reprocessing and Three Mile Island-2 which I transmitted to your staff as a result of our discussion at last Friday's cabinet meeting.

You will recall that we discussed how the nuclear option is a "must" in satisfying U.S. future demands for an abundant, reliable energy supply. We also agreed that this Administration needed to reverse the deterioration of our nuclear industry and restore the U.S. to a leadership position in the international nuclear community. This strategy requires:

- Establishment of a sound and supportive regulatory process.
- Advancement of the fast breeder reactor program.
- Development of Light Water Reactor (LWR) spent fuel reprocessing to close the nuclear fuel cycle and to support development and eventual deployment of breeder technology.
- Demonstration of capability for disposal of high level radioactive waste.

This four-point program is consistent with your pledge to the people last Fall and was included in the Republican Platform. Most of these initiatives have now been incorporated in your FY 1982 Budget by Director Stockman. These new starts dramatize your resolve to get America on the move again and sharply contrast against the muddled anti-nuclear posture of the previous Administration. The new specific initiatives which have been accepted for inclusion in your FY 1982 Budget are:

1. Fast Breeder Design and Supporting Technology, including construction of the Clinch River Breeder Reactor.

2. Acceleration of the U.S. program for Disposal of Nuclear Waste.

However, there are two issues which remain to be settled:

- Breaking the Three Mile Island-2 deadlock (FY 1982 cost is +$27M) and;
- Recapturing American leadership in reprocessing of spent nuclear fuel (FY 1982 cost is +$35M).

In each of the above cases, I have offset any increases in your FY 1982 Budget by decreases elsewhere within our overall nuclear program. The issues therefore, are clearly policy, not budgetary.

Attached for your information are brief summaries of these two issues. I look forward to an early meeting with you and Director Stockman so that we may get on with the task of restoring this Nation to a position of technological leadership in nuclear energy, and, thereby, strengthening both our domestic economy and international security.

Attachments

THREE MILE ISLAND INITIATIVE

ISSUE: Should DOE initiate an R&D program to break the log jam and expedite the cleanup and removal of the damaged core from Three Mile Island. This proposal requires $27M in FY 1982 and has a total cost over three years of $75M.

DISCUSSION:

This country, especially its regulators and industry, was largely unprepared for the nuclear accident at the second power plant unit on Three Mile Island (TMI-2) near Harrisburg, Pennsylvania on 28 March 1978.

The nuclear wastes from the cleanup are unusual for a commercial plant but not unlike certain DOE wastes. The most difficult task will be the removal of the core, largely unused for power production but highly radioactive and probably substantially damaged by high heat during the accident. Nuclear insurance covers only about $300 million of the cleanup costs of about $860M (in FY 1981 dollars) of which $199M were spent in 1979-1980. An additional $320M would be required to bring the plant back into operation (FY 1981 dollars).

The Federal Government and the private sector can deal with the technical and management tasks of the cleanup. The financial problem is more difficult: the utility's resources are insufficient; the Public Utility Commission has provided substantial but limited rate relief; and the liability is unclear (the utility has sued the Nuclear Regulatory Commission for $4 billion in damages). The restart of the undamaged Unit #1 on the island could greatly reduce the burden on the utility, help pay for the cleanup and reduce the need for replacement power from coal and oil, but NRC has not yet licensed it.

In order to complete the cleanup of TMI-2, three things must happen:

1. NRC allow TMI-1 to start up and produce revenues to relieve the financial problem of GPU. A firm program to finance TMI-2 cleanup is an absolute prerequisite to restart of Unit #1.

2. The Pennsylvania Public Utility Commission should approve all or much of the current GPU request before the Commission.

3. The Federal, state and utility roles be defined.

Early resolution of the log jam will probably result in contributions by the State of Pennsylvania to the cleanup of TMI.

Both DOE and OMB agree that the major TMI problems are institutional in nature and that resolution of regulatory issues is essential to proceeding with cleanup. DOE strongly feels that this initiative is the first step to resolution of those issues and that it will ultimately limit Federal involvement. The program has the following features:

1. Access to the core requires resolution of technical issues relative to treatment of radioactively contaminated liners resulting from processing of radioactive water and subsequent removal of same.

2. Examination of the core will confirm indications that damage and radiation release were substantially less than NRC anticipated in drafting its regulations.

3. DOE has unique capabilities and facilities to address TMI-2 safety and waste problems which must be resolved for reactor cleanup, a prerequisite to future use.

4. There historically has been no R&D program to address abnormal wastes such as TMI because of low probability of occurrence.

5. If DOE does not take initiative, GPU may go bankrupt, resulting in probable total Federal takeover and cleanup.

DOE activities will be limited to R&D for removal, packaging and shipment of contaminated resins and early access to the core to determine the extent of damage and the appropriate procedures for removal, packaging and shipment of the damaged core to a DOE site for examination. Only DOE has the facilities for examination, processing, and disposal of the core and resins. Specifically excluded are water removal and cleanup to provide access to the reactor vessel, which are the responsibility of GPU.

The DOE budget proposal is contingent upon seeking an agreement with GPU, the Pennsylvania Utility Commission and the NRC, and an equitable distribution of cleanup costs (limitation of government expenditures to approximately $75 million over three years).

Delay of this limited initiative, until legislation is passed, would increase the probability of receiving responsibilities similar to those for West Valley, and Uranium Mill Tailings (government responsibility is 90 percent).

DOE PROPOSAL:

Increase the Carter budget by $27 million in FY 1982 and authorize total DOE expenditure of ~$75 million over three years ($48 million in FY 1983 and 1984)* to provide the basis for overcoming the current impasse. This displaces less than 10 percent of the total cleanup costs and is not a Federal "bail-out" of GPU. This initiative recognizes that Federal leadership is needed to let the private sector solve this problem.

*This assumes core removal in 1983. If this is delayed by regulatory actions a higher cost will result.

Appendix B.2

Memorandum from the President of the United States, to the Secretary of Energy, "Decisions on Department of Energy Budget Appeal," March 20, 1981

THE WHITE HOUSE

WASHINGTON

March 20, 1981

MEMORANDUM FOR THE SECRETARY OF ENERGY

SUBJECT: DECISIONS ON DEPARTMENT OF ENERGY BUDGET APPEAL

As you know, I have approved the Department of Energy's request to add $27 million to its civilian nuclear budget in FY 1982 for the purpose of conducting research and development at the damaged Three Mile Island nuclear plant. As noted in the Department's request, the use of these funds is contingent upon an agreement between the Department, General Public Utilities, the Pennsylvania Utility Commission, and the U.S. Nuclear Regulatory Commission that will limit the Federal role to necessary research activities in support of private clean-up efforts.

Further, I have disapproved the Department's request for additional funds for use in connection with activities at the Barnwell, South Carolina reprocessing plant. I do not believe it would be appropriate for the Federal Government to acquire the Barnwell plant or to finance construction or operation of any of its facilities.

I wish to emphasize that the Department of Energy should consult with industry to determine which regulatory barriers are of greatest concern to it and, working with the Vice President's Task Force on Regulatory Relief, should develop recommendations for my further review on how to create a more favorable climate for private reprocessing efforts.

Ronald Reagan

cc: The Vice President

Appendix B.3

White House Policy Statement from Edwin Meese, III, Counselor to the President, to the Honorable Richard L. Thornburgh, Governor of the Commonwealth of Pennsylvania, October 19, 1981

THE WHITE HOUSE

WASHINGTON

October 19, 1981

Dear Governor Thornburgh:

In response to our meeting of October 1, 1981, as well as discussions with Senator Heinz and other members of the Pennsylvania congressional delegation, the Administration has undertaken a review of its participation in the clean-up of the damaged unit at the Three Mile Island generating station.

We agree that the clean-up entails a number of useful research and development activities of broad national benefit. In addition, the Federal Government has unique capabilities for ensuring the safe isolation and disposal of certain radioactive waste materials at TMI.

The Federal Government should limit its participation, however, to those activities that are of general benefit or that relate to its unique responsibilities under the Atomic Energy Act of 1954 to ensure safe disposal of nuclear waste. It would not be appropriate for the Federal Government to enter into an open-ended commitment to finance a fixed percentage of clean-up costs or to commit funds without regard to whether those funds were to be used for one of the two legitimate Federal responsibilities identified above.

The President is particularly aware of the need to resolve the apparent impasse that has prevented significant progress in the clean-up of TMI. For this reason, in February of this year he approved a request to the Congress for $37 million for use in a Department of Energy research and development program at TMI in fiscal year 1982. The work that will commence in 1982 is the start of an effort that will continue for the next three to four years. DOE intends to provide technical assistance to clean up the water in the building basement; remove and dispose of abnormal wastes not disposable at commercial sites; remove and evaluate the damaged reactor core; develop special tooling needed for early core access; and other appropriate activities consistent with these guidelines. The DOE program is described in greater detail in the agreements between the Department and the other parties to the clean-up.

We agree that it would be very helpful to have greater certainty concerning the availability of funding for this DOE program in years subsequent to FY 1982. Accordingly, I wish to assure you that the President intends to request from Congress sufficient funds in future years to complete the identified DOE program of research and development at TMI. This will include a total of approximately $75 million (including FY 1982) to carry out the program approved by the President last spring, as well as a total of $48 million (including previously appropriated funds) to complete the activities initiated under the agreement with EPRI.

As you noted in developing your outline of a plan for the TMI clean-up, the utility industry, the states of New Jersey and Pennsylvania, the owners of TMI, and the Federal Government all share an interest in a resolution of the problem. The responsibility for the financial burdens created by the TMI accident must rest primarily with those who produced and used the electric power from the facility, not the Federal Government. But to the extent that the Federal Government can bring certain unique experience to bear and to the extent that it can support research of benefit to the nation as a whole, it can appropriately participate in the clean-up. At this point, we should all focus our efforts on getting the clean-up completed as expeditiously and safely as possible.

As the President indicated to you during your recent meetings and telephone conversation, he appreciates your leadership in developing a cost-sharing plan which would break the impasse over the clean up of Three Mile Island. The conditional commitment by the national utilities industry to contribute $190 million to the clean up process is also a result of the active role you have taken in attempting to solve this problem. The President appreciates the opportunity to work with you, the Congress, the industry, and other parties in achieving a resolution to this situation.

Sincerely,

Edwin Meese III

Edwin Meese, III
Counsellor to the President

Honorable Richard L. Thornburgh
Governor
Commonwealth of Pennsylvania
Harrisburgh, Pennsylvania 17120

Appendix B.4

U.S. Department of Energy, U.S. Nuclear Regulatory Commission, "Revised Memorandum of Understanding Between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy Concerning the Removal and Disposition of Solid Nuclear Waste from Cleanup of the Three-Mile Island Unit 2 Nuclear Plant," March 15, 1982

Memorandum of Understanding
Between the
U.S. Nuclear Regulatory Commission
and the
U.S. Department of Energy
Concerning the Removal and Disposition of Solid Nuclear Wastes
from Cleanup of the Three Mile Island Unit 2 Nuclear Plant

I. Objective

This memorandum of understanding specifies interagency procedures for the removal and disposition of nuclear wastes resulting from cleanup of the Three Mile Island Unit 2 plant. This will help to ensure that the TMI Site does not become a long-term waste disposal facility.

II. NRC Roles and Responsibilities

The NRC has the responsibility under the Atomic Energy Act of 1954 as amended (42 U.S.C. 2011 et seq.), to regulate all licensee activities at the TMI-2 site, including waste management, and ensure these activities are carried out in accordance with the requirements of applicable rules and regulations and the requirements of Facility Operating License Number DPR-73, as modified by amendments or orders issued by the NRC. NRC will carry out its responsibilities by onsite observation of licensee activities. As required, policy, and technical support will be provided to the NRC TMI Site Office by NRC Headquarters and Regional Office(s).

NRC will work cooperatively and closely with the DOE, and will keep DOE fully and currently informed of NRC's activities.

NRC will continue to keep public, state and local officials informed of NRC's activities. When appropriate, NRC will involve DOE in these information exchanges with the public, state and local officials.

III. <u>DOE Role and Responsibilities</u>

Where DOE determines that generically beneficial research, development ano testing of the TMI-2 accident generated solid wastes can be carried out, DOE will perform such activities at appropriate DOE facilities. For those other wastes that cannot be disposed of in commercial low level waste facilities, DOE may also assume responsibility for removal, storage, and disposal to the extent that the licensee provides reimbursement to the DOE. These activities will be undertaken to the extent consistent with appropriate statutory authority. NRC licensing of DOE facilities that are utilized for storage, processing or disposal of TMI-2 accident generated wastes will not be required since these facilities have primary uses other than for receipt and storage of wastes resulting from licensed activities.

The DOE will provide technical support to the licensee and the NRC as deemed appropriate.

DOE will work closely with the NRC and keep NRC informed of DOE's activities.

IV. <u>Currently Identified TMI-2 Accident Generated Solid Radioactive Wastes</u>

The following lists those TMI-2 accident generated solid radioactive wastes which currently exist or are planned to be generated. This listing may be modified in the future as the cleanup progresses.

1. EPICOR-II System Wastes

Forty-nine ion exchange resin liners with loadings up to 1500 curies/liner are in temporary storage at the TMI-2 site. DOE plans to develop a prototype high integrity container (HIC), production units of which, if utilized by the licensee, may allow these liners to be acceptable for licensed disposal in commercial land burial facilities some 1-2 years from now. DOE is also performing characterization experiments on one of these liners and may find it desirable to extend its R&D program to other liners. Should a more expeditious handling of these wastes be required due to the potential for a limited release to the storage environment (which could cause public concern), a contingency plan will be implemented wherein DOE would at its discretion take receipt of these EPICOR liners on a reimbursable basis from the licensee for storage or disposal. Future EPICOR-II liners are anticipated to be loaded to allow commercial shallow land disposal offsite by the licensee.

2. Submerged Demineralizer System Wastes

It is anticipated that the dispersed radioactivity in accident generated water will be deposited on zeolites in submerged demineralizer system (SDS) liners. Due to the unique character and nature of these wastes, DOE will take possession of and retain these liners to conduct a waste immobilization research and development and testing program.

3. Reactor Fuel

Following removal of the damaged core from the reactor vessel, the entire core will be shipped to a DOE facility to survey and select those portions most appropriate for DOE's R&D program. Information obtained from detailed examinations is expected to be of generic benefit to design, fabrication and operation of reactor cores in a safe and efficient manner for current and future nuclear power plants. The remainder of the core will remain in storage at the DOE facility and will be ultimately disposed of under an agreement to be negotiated between DOE and the owner.

4. Transuranic Contaminated Waste Materials

As the cleanup progresses, some waste materials (e.g., sludges) may be found to be contaminated with transuranics at levels above which commercial low level burial facilities are authorized to accept. Alternatives for such material will be considered on a case-by-case basis and could include archiving, R&D evaluation or temporary storage onsite, or at a DOE facility awaiting further processing and/or disposal in a permanent repository offsite. Depending on the nature of these materials, DOE's activities could either take the form of an R&D program of generic value, or would be subject to reimbursement by the licensee.

5. Makeup and Purification System Resins and Filters

During the TMI-2 accident, the makeup and purification system demineralizer vessels and filters were highly contaminated by letdown of reactor coolant through the system. These resins and filters have not been characterized, however, based on radiation measurements, the resins and filters are believed to have specific activities well in excess of the loadings on the high specific activity EPICOR-II prefilters and are considered unsuitable for commercial land disposal. Due to the generic value of the information to be obtained and the very high specific activities of the filters, DOE will take possession and retain these filters for research and development activities. DOE will also take possession of and retain purification system resins either for an R&D program of generic value or for storage or disposal on a reimbursable basis.

6. <u>Other Solid Radioactive Wastes</u>

The low-level wastes associated with decontamination (e.g., some ion exchange media, booties, gloves, trash) will be disposed of by the licensee in licensed commercial low level burial facilities.

V. This Memorandum of Understanding will take effect when it has been signed by the authorized representative indicated below for each agency. DOE and NRC shall each have the right with the consent of the other party to modify this agreement.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Bernard J. Snyder (signature)

Bernard J. Snyder, Program Director
TMI Program Office
Office of Nuclear Reactor Regulations

Date: 3/15/82

FOR THE U.S. DEPARTMENT OF ENERGY

F E Coffman (signature)

Franklin E. Coffman
Deputy Assistant Secretary for
Nuclear Waste Management and
Fuel Cycle Programs
Office of Nuclear Energy
Date: 3/15/82

Appendix B.5

Agreement in Principle (between DOE and GPU Nuclear) for Acquisition of the Damaged TMI-2 Reactor Core by DOE
March 19, 1992

DOE Authorization for TMI

Agreement in Principle

Acquisition of the Damaged TMI-2 Reactor Core by DOE

Whereas, the Owners of Three Mile Island Nuclear Generating Station, Metropolitan Edison Company, Pennsylvania Electric Company, Jersey Central Power & Light Company, all subsidiaries of General Public Utilities Corporation, are desirous of completing the defueling, cleanup, and disposal of waste from the TMI-2 nuclear powerplant in as safe and efficient manner as possible, and

Whereas, it now appears likely that shipment of the bulk of the damaged fuel immediately upon removal from the reactor vessel offers significant advantages from a public health and safety as well as from a cost point of view, and

Whereas, the Department of Energy (DOE) is authorized to conduct a research and development program to examine the damaged reactor core so as to enhance understanding of degraded core performance and thereby contribute to nuclear reactor safety on a generic basis, and

Whereas, acquisition of the entire TMI core will significantly enhance the value of the research and development program and its potential usefulness in evaluating generic reactor safety matters:

It is therefore agreed that:

1. The Department will acquire ownership of the damaged core from the Owners at no cost to DOE.

2. The Department will arrange for shipment of the entire core to a DOE site for an examination program. Title to, and responsibility for, the damaged fuel will be transferred to the DOE upon leaving the TMI site boundary.

3. The Owners will reimburse cost of shipping to a DOE site.

4. The Department will fund the cost of interim storage, survey of the core, and selection of samples for detailed examinations, a program expected to take about 3 to 5 years.

5. The Owners will reimburse costs associated with storage (beyond the R&D period referred to in item 4) and disposal, up to a reasonable value to be agreed upon. The cost to be reimbursed shall not exceed that which the Owner would incur in storage of a TMI type core in a TMI-1 fuel pool awaiting ultimate disposition, and for ultimate disposal in a Government repository.

6. This Agreement is contingent upon negotiation and execution of a written contract between DOE and the Owners, which contract shall define the particulars to a degree satisfactory to all parties.

3/15/82 | 3/19/82
On Behalf of the Owners | On Behalf of the Department of Energy

Appendix C

Information and Data Requirements from the Core Contract (Appendix B of DOE Contract No. DE-SC07-ID12355)

APPENDIX B

INFORMATION AND DATA REQUIREMENTS

Information and data must be developed by both DOE and the Company (herein referred to as GPUNC) and furnished to the other party in order for each party to accomplish its responsibilities. The following tabulation specifies the information to be provided, the responsible party and need date. In the event that there is a change in any data provided by one party to the other, the change will be promptly communicated.

Information and Data	Developed By	Furnish To Other Party
I. SHIPPING CASKS		
1. Number and types of casks available including for each the cask description: a. Cask surface finish b. Dimensions c. Weight d. Material of construction e. Liquid coolant used in the cask and its weight or volume	DOE	On on-going basis consistent with agreed shipping schedules.
2. Describe the cask handling devices required: a. Type of load bar required. b. Special lid-removal tools c. Copy of procedures for handling cask at reactor site.	DOE	On on-going basis consistent with agreed shipping schedules.
3. Furnish one copy of the Safety Analysis Report for the shipping cask.	DOE	6 Months Prior To Tender for Acceptance (MPT)
4. Furnish NRC Certificate of Compliance.	DOE	3 MPT
5. Furnish the decontamination procedures or precautions.	DOE	3 MPT
6. Furnish complete list of DOE requirements to be satisfied by GPUNC for DOE receipt of a fuel shipment	DOE	12 MPT

II. FUEL CANISTER UNITS

TMI-2 core material must be shipped in canisters because of its configuration. Following core material loading, the canisters must be prepared commensurate with shipment and long-term underwater storage. Control of radiolytic gases must be provided commensurate with shipment and long-term underwater storage. One or more canister designs may be employed. The following information must be supplied:

1. Final assembly drawing of the canister design.	GPUNC	15 MPT
2. Maximum quantity of fissile material to be allowed in each canister.	GPUNC	15 MPT
3. Composition and related data for the canister excluding contents. a. Chemical compositon of all components b. Weight in air of empty canister c. Sealing method d. Composition of gaskets, if used e. Dimensions.	GPUNC	15 MPT
4. All penetrations into canister.	GPUNC	15 MPT
5. Any extraneous material associated with canister or contents (pyrophoric or reactive materials, inert materials, etc.).	GPUNC	15 MPT
6. Describe handling fixture(s) on the cansister and identify any special tools required.	GPUNC	15 MPT
7. Fuel material loading technique(s).	GPUNC	12 MPT
8. Draining, if applicable, radiolytic gas control, and leak testing procedures.	GPUNC	12 MPT
9. Thermal analysis of canister and contents (worst case), both in water and in air.	GPUNC	12 MPT
10. Technique(s) to be used to document canister contents during core material loading operations.	GPUNC	3 MPT

11.	Anticipated fuel canister loading limitations by volume and weight.	GPUNC	3 MPT
12.	Furnish the results of any criticality calculations generated for storage at the reactor site.	GPUNC	3 MPT
13.	Describe serial number identification logic to be used to identify canisters, contents, and differences in canister design, as applicable.	GPUNC	12 MPT
14.	Describe the poison, poisoned inserts or spacing insert necessary for shipping the particular fuel canister unit(s).	GPUNC	12 MPT
15.	Provide fuel canister unit serial number(s).	GPUNC	7 Days Prior to Tender for Acceptance (DPT)
16.	Provide canister as-built drawings.	GPUNC	7 DPT
17.	Provide weight (wet) and calculated dry weight and density of canister and contents.	GPUNC	7 DPT
18.	Verify adherence to procedures in Item 8 above.	GPUNC	7 DPT
19.	Furnish any visual record made of core material during canister loading, e.g., videotapes.	GPUNC	7 DPT
20.	Provide detailed canister-loading inventory describing fuel canister unit contents. Canister inventory must be as descriptive as possible, e.g., "loose granular debris from lower reactor vessel internals," "fused core debris, approximate lengths in inches, no end boxes or spacer grids," "approximate number of upper end boxes, no fuel rods," et cetera. Non-core materials, except as required for safe shipment and long-term underwater storage, are not to be placed in the canisters, however, if any such materials are unavoidably included, the inventory must identify item materials in detail.	GPUNC	7 DPT

Appendix D

Modifications to NuPac's Cask Supply Contract

APPENDIX D

Modifications to NuPac's Cask Supply Contract

The price agreed to for the original contract with NuPac for the casks was $2,152,806. Before the contract was closed, the price for 13 modifications to the contract involving dozens of deliverable items and payment for incentive for early delivery of the casks was $4,494,874. This amount included costs for equipment purchased by EG&G Idaho on behalf of GPU Nuclear as described below in the summary for modification number 9. Including EG&G Idaho's material handling and overhead costs, GPU Nuclear reimbursed EG&G Idaho approximately $1,000,000.

A summary of the contract modifications and prices is as follows:

Original contract price was for 2 complete casks at $1,076,403 each for a total of $2,152,806. The scope included:

2 OCVs with overpacks

2 ICVs

2 shipping skids

2 railcars

1 vertical lift fixture

1 NRC Certificate of Compliance

The original contract included an incentive for NuPac to deliver the casks much earlier than proposed. Delivery was accelerated from June 1, 1986 for the first cask and March 15, 1987 for the second cask, to December 15, 1985 and January 15, 1986 respectively. The maximum value of the incentive was $150,000.

When the cask supply RFP was issued, the requested delivery date for the first cask system was based on a start of defueling in July 1986. NuPac committed to meeting EG&G Idaho's requested date in their proposal. After the RFP was issued, GPU Nuclear accelerated the planned date for start of defueling to July 1, 1985. EG&G Idaho requested an early delivery of the casks from NuPac to attempt to meet the core contract's obligation to ship loaded canisters within 90 days after being loaded with fuel debris.

Modification No. 1 increased the price by $380,338 for the following items:

Quarter scale drop test	$269,951
1 lifting yoke	$ 27,387
1 horizontal lift frame	$ 55,590
2 plastic scale models	$ 13,705 each

The need for a quarter scale drop test program was based on meetings held with the NRC Transportation Certification Branch. Approval of the cask design was expected to require less time for review if results from a successful test program could be submitted in the cask Safety Analysis Report (SAR). The lifting yoke and frame were needed for cask handling at INEL as described in Section 2.7. The plastic models were one-tenth scale replicas of the cask on its shipping skid. The models were helpful in explaining the cask components and functions to various audiences including operators, the media and the general public.

Modification No. 2 increased the price by $305,265. The load carrying capacity of the two railcars was increased at a total price for both railcars of $274,597. The need for an increase in capacity is discussed below under Modification No. 4 and in Section 2.5.4. The balance of the price increase was for travel to TMI-2 to meet with the NRC and to attend Core Shipping Technical Working Team Meetings on a regular basis.

The modification also revised the dates for which NuPac would receive an incentive under the contract for early delivery of the casks. Performance of the quarter-scale drop tests by Sandia National Laboratories was delayed by two weeks from the schedule agreed to with NuPac. The revised dates were December 30, 1985 for the first cask and January 30, 1986 for the second cask.

Modification No. 3 increased the value of the incentive for early delivery by a maximum of $167,000 and required NuPac to meet the previous December 15, 1985 and January 15, 1986 dates for delivery of the casks. These dates had gained a high profile in commitments made by DOE and were the basis for other program planning. GPU Nuclear was succeeding in their attempt to start an early defueling of the core. EG&G Idaho was proceeding with development of core boring equipment and anxious to obtain samples for delivery to the INEL for examination. NuPac had completed the quarter-scale drop test program and was confident that the design of the cask could be built as submitted to NRC in the cask SAR. The incentives were to pay for costs to accelerate the manufacturing processes for the casks which were underway.

Modification No. 4 increased the price $115,913 because of a change in canister diameter. Reflecting the dynamics of the cask and canister systems integration problem, the canister's length had changed from the original 170 inches for a full-length fuel assembly to 132 inches when the M-130 rail cask was under consideration. After receipt of the cask proposals in June 1984, canister length was increased to 150 inches which was the maximum length specified by potential suppliers.

While changes in canister length were accommodated by GPU Nuclear's programs without considerable impacts, the canister diameter change requested by GPU Nuclear had noticeable effects on the cask. The canister's diameter had been set by GPU Nuclear for use by EG&G Idaho in the RFP for the cask supply. But, by the time the cask contract was awarded, the canister design process determined that an increase in the outer diameter from 13.25 inches to 14 inches was desirable.

GPU Nuclear's proposed canister diameter increase considered the following factors. The boral plate shroud assembly for the fuel canister design would be an off-the-shelf-design item for a 14 inch diameter canister but would need to be redesigned for a smaller diameter canister. A shroud for a 14 inch diameter canister would have a relatively larger cross-sectional area than for the smaller diameter canister and would make loading of damaged fuel assemblies an easier task. Larger diameter canisters would have a larger volume per canister for loading fuel and require fewer canisters to load the entire core. A larger outer diameter was needed for the hydraulic performance of the knockout canisters since smaller diameter canisters would have increased flow velocities and less settling of small particles.

The technical bases for the small increase in outer diameter from 13.25 inches (May 1984) to 14 inches (August 1984) were sufficient for EG&G Idaho to change the canister interface requirements specified in the cask supply contract. The small increase in canister diameter caused a corresponding increase in diameter in each of the seven tubes that formed the cavities for the canisters in the ICV. The outer diameter of the ICV and the OCV's inner and outer diameters were then also forced to increase. The net affect was a slightly larger and heavier cask than originally proposed and a change in contract price to accommodate the revised canister diameter. The heavier cask necessitated a higher load capacity railcar.

Modification No. 5 decreased the price by ($68,082). The price originally proposed by NuPac included this amount as a licensing fee to be paid to NRC for review of the cask application by the Transportation Certification Branch. This fee was not required to be paid to NRC since the Certificate of Compliance was issued to DOE and NRC did not charge DOE for review of the shipping package application.

Modification No. 6 increased the price $54,005. Changes to the structural design of the knockout canister were identified by GPU Nuclear in January 1986, well after award of the cask supply contract. NuPac had already completed many of the cask criticality analyses. The canister's design change caused an increase in the reactivity from 0.87 to 0.91 K-effective. Additional criticality analyses were needed to accommodate the revised canister design.

Modification No. 7 had no effect on price. A change was made to clarify the delivery date for the NRC Certificate of Compliance under the incentive clause of the contract. The NRC's approval was required to be provided with the delivery of the second rather than the first cask.

Modification No. 8 increased the price by $57,384. Approximately half of this amount was for NuPac to provide technical support in development of a full-scale drop test program for a knockout canister discussed in Section 2.5.3.3. The second change was another revision to the criticality analysis for the cask due to a necessary change in the worst-case criticality analysis for a type of canister. This time, the criticality analysis for filter canisters was revised to account for the fact that only small size fuel particles could enter into such canisters. The smaller size particles were less reactive than pellet size pieces and lowered the reactivity of a filter canister. The scope included revision of the SAR to incorporate both the results of the knockout canister drop tests and the revised filter canister criticality analyses.

Modification No. 9 increased the price by $1,091,000. This scope change represents addition of a specially designed cask handling equipment for use at TMI-2 as described in Section 2.6. The total price reflects a sharing of the cost by both EG&G Idaho and GPU Nuclear. EG&G Idaho had responsibility for the shipping casks and transport skids while GPU Nuclear had responsibility for cask handling equipment at TMI-2. However, because the design of the cask and skid directly influence the handling equipment, management of both organizations agreed that the purchase of cask handling equipment would be made part of EG&G Idaho's subcontract with NuPac but be the financial responsibility of GPU Nuclear. EG&G Idaho was financially responsible for less than one-third of the price since only part of NuPac's cost was for modification of equipment in EG&G Idaho's original scope of supply.

Modification No. 10 had no effect on price. A change was made to extend the delivery date for the NRC's approval of the cask design under the incentive clause of the contract. NRC's review had been a priority based on the urgency of the cleanup of TMI-2. However, an accident involving the filling of a shipping package at another facility interrupted the TMI-2 cask's review.

Modification No. 11 increased the price $21,941 for supply of a pressure rise leakage rate test system for use on the containment boundary seals of the cask. The scope included design, fabrication testing, calibration, and a leakage rate test procedure.

Modification No. 12 increased the price $53,579 for work related to the cask auxiliary handling equipment and cask unloading station (CUS) used at TMI-2. Additions to the scope included minor modifications to the equipment that were identified as useful based on the Integrated Test of the handling systems at Westinghouse Hanford Company (WHC) before delivery to TMI-2. Also, NuPac supplied test weights for simulating the canisters at WHC and brackets for use with the skid at TMI-2. EG&G Idaho obtained a fixture for testing the lift fixtures used at the INEL.

Modification No. 13 increased the price $13,725 for technical support in resolving NRC's concerns with a weld indication on a radiograph and performing a helium leakage rate test at the TMI site.

Appendix E

GAO Audit Decision on NAC's Protest

United States Government

memorandum

Department of Energy
Idaho Operations Office

DATE February 4, 1985

SUBJECT NAC Protest

TO Addressees Listed Below

Please make distribution to Procurement, EG&G personnel and others as appropriate.

Brett R. Bowhan

Brett R. Bowhan, Attorney
Office of Chief Counsel

Attachments

Addressees
Dave Letendre
W. O. Crownover
Ron Cordes
W. Bixby
P. Hamric
W. Young

RECEIVED

FEB 08 1985

DECISION — THE COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

FILE: B-216076 DATE: January 24, 1985

MATTER OF: Nuclear Assurance Corporation

DIGEST:

1. Federal Procurement Regulations do not apply per se to a cost-type managing and operating prime contractor of the Department of Energy; rather, a prime contractor must conduct procurements according to terms of contract with agency and its own procedures and conform to the federal norm.

2. Where, even assuming validity of protester's allegation that its proposal should have been considered technically acceptable, firm's offer is not low, firm has not been prejudiced by agency determination that its proposal is technically unacceptable since award was made on basis of initial proposals to low cost, technically acceptable offeror.

3. Unfair or prejudicial motives will not be attributed to procurement officials on the basis of inference or supposition. Allegation that award to a firm resulted from preselection or preference for the awardee is denied where it is not supported by record.

4. Protester has burden of affirmatively proving that agency's technical evaluation was unreasonable, and protester's disagreement with agency's technical evaluation that proposal met solicitation requirements for a design which minimized potential radiation exposure is not sufficient, in itself, to satisfy this requirement.

5. Allegation that awardee is not capable of performing the contract because it lacks both financial and production capacity concerns matters of responsibility. GAO will not review a Department of Energy operating contractor's affirmative determination of responsibility absent a showing of fraud or bad faith or that definitive responsibility criteria in the solicitation were not applied.

6. Allegation that protester failed to receive adequate debriefing and that contracting officer awarded contract after receiving notice of protest does not affect the validity of award.

Nuclear Assurance Corporation (NAC) protests the rejection of its proposals under request for proposals (RFP) No. C84-130482, by EG&G Idaho, Inc. (EG&G), the managing and operating contractor for the Department of Energy (DOE) technical integration office at the Three Mile Island (TMI) site and the DOE Idaho National Engineering Laboratory (INEL) in Idaho, and the award of a contract under this RFP to Nuclear Packing Corporation (NUPAC). The RFP solicited shipping casks and transportation for the shipment of nuclear waste from TMI to INEL. NAC submitted one proposal based on casks it owned, and also submitted a joint proposal with National Lead Incorporated (NLI) offering NLI casks. EG&G awarded the contract to NUPAC on the basis of initial proposals without discussions.

NAC contends that EG&G improperly rejected its proposals on the basis of criteria not stated in the RFP and that, based on the stated RFP requirements, NAC's proposals were technically acceptable. NAC further alleges that actions by EG&G and DOE demonstrate that NUPAC was pre-selected for award and, as a result, proper consideration was not given to other offers. NAC also questions the award to NUPAC, arguing this award failed to take into consideration time and safety factors related to the transportation of radioactive nuclear waste and was contrary to RFP radiation exposure level requirements. Also, NAC alleges that EG&G and DOE should have rejected NUPAC because it lacks both the financial and production capability to perform this contract. Finally, NAC contends it was the low offeror under this RFP and properly should have received the award. NAC requests that the contract with NUPAC be terminated and award be made to NAC or, at a minimum, the procurement be reopened and discussions conducted with offerors.

We dismiss the protest in part and deny it in part.

<u>Background</u>

DOE established a research and development program to examine the damaged TMI unit 2 reactor core to enhance understanding of degraded core performance and contribute to nuclear reactor safety. As part of this program, DOE is to arrange for transportation, storage and disposal of the core material from the TMI unit 2 reactor station. DOE designated EG&G to contract for these supplies and services. In January 1983, DOE requested EG&G to plan the management of the transportation aspects of the TMI-2 core, including shipping, safety analysis, cask lease arrangements and transportation coordination. After EG&G determined the scope of work for core transportation, it submitted the requirements for DOE's approval. In June 1983, DOE authorized EG&G to proceed with an RFP. RFP No. C83-130244 was issued in August 1983, limiting the procurement to truck casks. During the pendency of that procurement, due to new developments, EG&G initiated a study to evaluate the possible use of government-owned rail casks. While government-owned shipping casks apparently were not available, the study showed that commercial alternatives could meet the government's needs. By March 1984, EG&G had initiated evaluation of the proposals and began to negotiate with qualified offerors. However, based on the study, DOE and EG&G determined that the procurement should be expanded to also solicit a rail cask alternative and provide for certain other changes regarding cask requirements.

The original RFP was canceled and a new revised RFP, No. C84-130482, was issued which solicited proposals on separate inner containment vessels for each cask proposed as required by Nuclear Regulatory Commission (NRC) regulations at 10 Code of Federal Regulations § 71.63 (1984) and transportation management services. Offerors were to submit a proposal for a cask with a single level of containment or with an optional inner containment vessel, a "double containment" option. The RFP also solicited transport equipment. The RFP advised that award would be made to the firm whose proposal was determined to be most advantageous to EG&G, price and other factors considered. EG&G reserved the right to award the subcontract at its discretion to any offeror other than the one proposing the lowest price on the basis of its evaluation of the acceptability of the technical proposals, total cost, and offeror's qualifications. The RFP also stated that award could be made without discussions and that proposals should be submitted initially on the most favorable terms of price, technical acceptability, completeness and the stated evaluation criteria. A preproposal conference was held which further clarified the RFP.

DOE reports that eight proposals were received containing designs intended to meet the double containment requirement. Although, apparently, the option of conducting written discussions was considered, EG&G decided to award to NUPAC because it was the only offeror considered technically acceptable and its price was the lowest offered. DOE reports that EG&G determined that discussions were inadvisable because "the danger of technical transfusion would be unavoidable."

Application of Federal Acquisition Regulation (FAR) to this procurement

Initially, NAC asserts that because of alleged extensive involvement by DOE in the conduct of this procurement, EG&G was in effect DOE's purchasing agent and, accordingly, the FAR is applicable to this procurement. DOE concedes that EG&G conducted this procurement "for" DOE and, accordingly, GAO has jurisdiction to review this procurement under our decision in Optimum Systems, Incorporated - Subcontract Protest, B-183039, Mar. 19, 1975, 75-1 C.P.D. ¶ 166. See also J. F. Small & Co., Inc.--Reconsideration, B-207681.3, July 14, 1983, 83-2 C.P.D. ¶ 89. However, DOE asserts that EG&G was not DOE's purchasing agent and DOE did not participate directly in the award selection process.

Referring to our decision in J. F. Small & Co., Inc.,--Reconsideration, B-207681.3, supra, DOE contends that the procurement generally is not subject to the statutory and regulatory requirements, such as FAR, which govern direct DOE procurements. DOE states that our review should be limited to ensuring that EG&G adhered to the "Federal Norm," that is, that the prime contractor complied with fundamental principles of federal procurement. See Piasecki Aircraft Corporation, B-190178, July 6, 1978, 78-2 C.P.D. ¶ 10 at p. 9.

The record shows that EG&G prepared the RFP and evaluated proposals. Under these circumstances, where DOE's involvement is essentially limited to approval of EG&G's award, we have consistently recognized that a DOE contract manager, such as EG&G, is not a purchasing agent for the government. J. F. Small & Co., Inc.--Reconsideration, B-207681.3, supra; see also United States v. New Mexico et al., 455 U.S. 720 (1982). Thus, we conclude that federal norm standards apply here.

Propriety of award without discussions

With regard to the propriety of the award to NUPAC, an award may be made on the basis of initial proposals without discussions, where it can be demonstrated clearly from the existence of adequate competition that acceptance of the most favorable initial proposal without discussions would result in a fair and reasonable price, provided that the solicitation advises offerors of the possibility that award might be made without discussions and provided that award is in fact made without discussions. Emerson Electric Co., B-213382, Feb. 23, 1984, 84-1 C.P.D. ¶ 233.

With regard to the prices offered, NUPAC's cost for the purchase of two rail casks with NRC certification and two rail cars and auxiliary equipment is $2,191,028. NAC's proposed cost of $1.9 million had to be adjusted to provide for the cost of two rail cars required under the RFP which NAC did not offer. Based on its survey of rail car costs, EG&G determined that the ultimate cost of NAC's purchase proposal, adjusted for rail car costs, would be $2.3 million.

With regard to NAC/NLI's proposal, the agency reports that NAC/NLI's proposal, in addition to being considered technically unacceptable, provided for a price of $25,632,400, which EG&G considered unacceptable. The record shows that both the NAC proposal and the NAC/NLI offer were priced higher than NUPAC's purchase offer. Under these circumstances, even if NAC is correct concerning the improper rejection of either of its offers, and its casks were technically acceptable, NUPAC's offer remains the most favorable price offered. Thus, if award to NUPAC was otherwise proper, NAC was not prejudiced by EG&G's finding that its two proposals were technically unacceptable since award was based on lowest price. See Centennial Computer Products, Inc., B-211645, May 18, 1984, 84-1 C.P.D. ¶ 528.

Allegation of improper preference for awardee

The protester alleges that NUPAC was "preselected." DOE correctly points out that a showing of bad faith or bias requires undeniable or irrefutable proof that the agency had a malicious and specific intent to injure the party alleging bad faith. Further, we will not find a discretionary action to be biased or arbitrary if the record indicates a reasonable basis for such action. CMI Corporation, B-209938, Sept. 2, 1983, 83-2 C.P.D. ¶ 292. Thus, even if it is assumed that the agency had a bias against NAC in favor of NUPAC, it must be shown that it was translated into action which affected NAC's competitive position. See Optimum Systems, Inc., 56 Comp. Gen. 934 (1977), 77-2 C.P.D. ¶ 165.

In our view, NAC has not submitted evidence meeting the heavy burden of proof imposed on any party alleging bad faith, bias or arbitrary action by an agency. For example, NAC alleges the solicitation called for a "time-is-of-the-essence" clause in the contract, and that this requirement was omitted from NUPAC's contract and, thus, shows an unfair preference to award to NUPAC. However, an addendum to the RFP, based on the preproposal conference meeting notes, clearly shows that a requirement for such a clause was not to be part of the contract. Thus, all offerors were on notice that this was not a requirement and all offerors were to submit offers on this basis.

Also, NAC claims that a selection of NUPAC was made by DOE and EG&G on March 30, 1984, and that NUPAC was visited in April 1984 to discuss lease arrangments under this RFP. DOE explains that a preliminary selection of NUPAC was made under the prior RFP, No. C83-130244, and negotiations initiated with NUPAC as one of two technically acceptable vendors. However, as noted previously, EG&G canceled the initial RFP because the scope of supply was broadened to include rail casks. The RFP which is the subject of this project was issued on May 9, 1984, and NUPAC submitted a "revised proposal" which included a rail cask proposal. NAC has not shown how these events show a preselection of NUPAC.

NAC also alleges that EG&G's acceptance of NUPAC's proposal was based on the fact that NUPAC offered more than the RFP required. However, since NUPAC's purchase proposal cost was low, even if the allegation is correct, NAC was not prejudiced since low cost was the basis of award.

NAC also points out that in the preproposal minutes incorporated into the RFP by amendment, EG&G stated its preference for leasing. NAC alleges that in making the award, EG&G disregarded this preference, and that since NAC's lease cost was lower than NUPAC's, the circumstances show a predisposition towards NUPAC.

We note that the complete minutes regarding this issue read as follows:

> "Question 8: Is there any preference for lease versus purchase?
>
> "Answer: Because of the uncertainty in shipping schedule, a flexible lease arrangement would be preferred."

The conference minutes show that EG&G did not necessarily exclude the purchase option, and the RFP clearly solicited purchase costs. In this connection, DOE points out that the awardee's purchase price of its cask is less than the NAC lease cost; the purchase price of NUPAC's cask is lower than NUPAC's lease price, and NUPAC's purchase price was less than the purchase price of both NAC's proposed casks. Under these circumstances, the agency's decision to award to NUPAC for the purchase of casks was reasonable and permissible under the terms of the RFP.

In short, none of these allegations provide evidence of preselection of NUPAC or biased conduct by EG&G in favor of NUPAC as alleged.

Allegation concerning acceptability of NUPAC's proposal

NAC challenges award to NUPAC on the grounds that "ALARA" (as low as reasonably achievable) principles for radiation exposure levels were not considered as required by the RFP. The protester contends that the selected cask design does not provide for a radiation exposure level lower than those offered by NAC and, thus, award to NUPAC violated ALARA regulations. Accordingly, NAC argues the award should be terminated and the procurement reopened.

Concerning the technical evaluation of proposals, the same standard of review applicable to direct federal procurements applies in this instance. Piasecki Aircraft Corporation, B-190178, supra, at p. 10. In this connection, we have stated that it is not the function of our Office to make determinations as to the acceptability or relative merits of technical proposals. Rather, we will examine the record and determine whether the judgment of the contracting agency was clearly without a reasonable basis. Unless such a finding is made, or there is an abuse of discretion, or a violation of procurement statutes or regulations, that judgment will not be disturbed. See Joseph Legat Architects, B-187160, Dec. 13, 1977, 77-2 C.P.D. ¶ 458, and cases cited therein; Struthers Electronics Corporation, B-186002, Sept. 10, 1976, 76-2 C.P.D. ¶ 231.

EG&G reports that NUPAC's proposal met the ALARA requirements. EG&G advises that 10 C.F.R. § 20.1(c) states that the term "as low as reasonably achievable" means as low as reasonably achievable taking into account the state of technology, the costs of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations in relation to the utilization of atomic energy in the public interest. EG&G determined that the cask design chosen minimizes exposure of radiation to workers during the loading of the canisters into the cask and during the essential decontamination and leak testing operations and also provides for protection of transporation personnel and the public during transport. The protester merely disagrees with EG&G's technical judgment. The protester has the burden of affirmatively proving its case, and a protester's technical disagreement with the evaluation of a proposal does not, in itself, satisfy this requirement. A.B. Dick Company, B-211119.3, Sept. 22, 1983, 83-2 C.P.D. ¶ 360.

Allegation concerning awardee's capability

NAC also contends that EG&G failed to consider time and safety in its award decision, which was contrary to the RFP, and, thus, NUPAC's proposal should have been rejected. Specifically, NAC alleges that NUPAC is not capable of producing a safe NRC-certified cask within the long-established time schedule for the TMI project at the cost proposed. This is not an issue for our consideration.

Essentially, an offeror's ability to satisfactorily perform at its proposed price is a matter of responsibility. EG&G found NUPAC responsible at the time of award. Because a decision concerning responsibility involves the exercise of considerable discretion and judgment, our Office generally will not review an affirmative determination of responsibility absent a showing of fraud or bad faith, or that definitive responsibility criteria in the solicitation were not applied. Ebonex, Inc., B-213023, May 2, 1984, 84-1 C.P.D. ¶ 495. Neither exception applied here.

Similarly, the protester's contention that the awardee lacks the requisite financial capability concerns the firm's responsibility, that is, whether it has the ability to meet the contract's requirements. See AAA Engineering and Drafting, Inc., B-213108, Oct. 11, 1983, 83-2 C.P.D. ¶ 442. EG&G did find NUPAC financially responsible on July 25, 1984, and, subsequently, awarded NUPAC the contract. As stated above, we will not review an affirmative determination of responsibility except under circumstances not applicable here. AAA Engineering and Drafting, Inc., B-213108, supra.

Allegation of procedural irregularities concerning award

NAC also alleges that EG&G awarded the contract after NAC had filed its protest in violation of the FAR. Even if we assume NAC is correct in its contention that NAC filed a protest before the award, a deficiency of this type is a procedural one which does not affect the validity of an otherwise proper award. The Singer Company, B-211857; B-211857.2, Feb. 13, 1984, 84-1 C.P.D. ¶ 177.

Similarly, with regard to NAC's contention that it received an inadequate debriefing, even if this were the case, it does not affect the propriety of the award.

The protest is dismissed in part and denied in part.

Milton J. Socolar
for Comptroller General
of the United States

Appendix F

GPU Nuclear Procedures and Safety-Related Documents for Canisters, Canister and Cask Handling, and Preparations for Shipping

Appendix F

GPU Nuclear Procedures and Safety-Related Documents for Canisters, Canister and Cask Handling, and Preparations for Shipping

GPUN CANISTER OPERATING PROCEDURES

TMI-2 Administrative Procedure Canister Vessel Traveller Data

This procedure provided a convenient means for recording and retaining specific information related to defueling canisters from their delivery onsite, through use, storage, preparation for shipping and ultimately, release for shipping offsite. This procedure generated a data package for each canister which travelled with the canister from receipt inspection until shipment. This tracking procedure was not intended to replace existing systems or documents used by any division within or external to TMI-2, but rather to supplement existing systems by capturing and maintaining certain selected data as responsibilities for, and custody of, the canisters changed among divisions.

TMI-2 Operating Procedure Canister Handling and Closure Operation

This procedure provided operating instructions for handling empty fuel, filter, and knockout canisters, inspecting fuel canister surfaces, and installing the fuel canister closure lid.

TMI-2 Operating Procedure Operation of In-Vessel Dewatering System

This procedure provided the operating instructions for installing/removing pressure relief valves, temporary relief valves, and Hansen coupling caps, plugging inlet and outlet connections, and dewatering defueling canisters located in the reactor vessel.

TMI-2 Operating Procedure Fuel Handling Building Defueling Operations

This procedure covered all operations of loaded fuel, filter, knockout, and defueling water cleanup system filter canisters after initial storage in the "A" spent fuel pool. Those operations included retrieval and return to storage; transfer to and from the dewatering station; transfer to the shipping platform; canister monitoring and sampling; canister dewatering and inerting; canister disinfection; and preparation for shipping including plugging and relief valve removal. This procedure also provided for recirculation sampling and processing of the dewatering system hold–up tank and backfilling canisters from the dewatering system tank.

TMI-2 Operating Procedure Fuel Canister Closure Head Removal, Gasket Replacement, Repair, and Closure

This procedure provided instructions for removing the closure head from a fuel canister, removing the metal gaskets, installing ethylene propylene diene monomer gaskets, effecting minor surface repairs and reinstalling the closure head.

TMI-2 Operating Procedure NuPac 125-B Cask Assembly

This procedure provided sufficient direction for the use of the NuPac 125-B rail cask as a licensed radioactive transport container.

TMI-2 Operating Procedure NuPac 125-B Rail Cask Disassembly

This procedure provided sufficient direction for the use of the NuPac 125-B rail cask as a licensed radioactive transport container.

TMI-2 Operating Procedure NuPac 125-B Rail Cask Loading

This procedure provided the direction and guidance necessary for the loading of the NuPac 125-B rail cask.

TMI-2 Operating Procedure NuPac 125–B Maintenance Verification Leak Tests

This procedure provided direction for performing the required maintenance verification leak test on the NuPac 125-B rail cask. The maintenance verification leak test covered the same areas and had more demanding acceptance criteria than the assembly verification leak test identified below. Because the maintenance verification leak test was easier to perform, less time consuming, and more stringent than the assembly verification leak test, the maintenance verification leak test was the only test performed prior to every cask shipment.

TMI-2 Operating Procedure NuPac 125-B Assembly Verification Leak Tests

This procedure provided directions for performing an assembly verification leak test on the NuPac 125-B rail cask.

TMI-2 Recovery Operations Implementing Procedure Defueling Canister Receiving, Inspection, and Staging Procedure

This procedure provided instructions for receipt and verification of defueling canisters from the fabricator, staging canisters prior to transfer into the reactor building or fuel handling building, and preparation of fuel canister closures.

TMI-2 Operating Procedure FHB/Fuel Transfer Cask Loading Station Decon Spray System

This procedure provided instructions for operating the fuel handling building/fuel transfer cask loading station decon spray system and for "A" spent fuel pool chemistry boron stabilization.

TMI-2 Operating Procedure Removal and Installation of NuPac 125-B Cask Cover and Overpacks

This procedure provided instructions for removing and installing the cask cover and overpacks in keeping with use of the NuPac 125-B rail cask as a licensed radioactive transport container.

Safety Evaluation Report for Canister Handling and Preparation for Shipment, SER 15737-2-607-111

This SER demonstrated that all planned activities associated with the transfer of the defueling canisters from spent fuel pool "A" to the NuPac 125-B shipping cask and the onsite activities associated with the shipping cask could be accomplished without causing unacceptable risk to the health and safety of the public.

System Description for the TMI-2 Defueling Canister Dewatering System, SD 3525-014

This SD identified the components, performance characteristics, arrangements, instruments and controls, valves, monitoring, interfaces, and so forth for the canister dewatering system.

The dewatering system removed and filtered the water from submerged defueling canisters and provided a transfer path to the defueling water cleanup system or the miscellaneous waste hold–up tank for future processing. The dewatering system also provided the cover gas for canister shipping. The water was removed from the defueling canisters to: (1) reduce the weight of the canisters for shipping, and (2) prevent the hydrogen/oxygen catalysts from being submerged. Argon cover gas was provided to: (1) reduce water intrusion when the canister was in the water, (2) reduce air intrusion when the canister is out of the water, and (3) reduce the pyrophoricity potential of the debris within the canister.

Technical Evaluation Report for the Fuel Canister Storage Racks TER 3253-012 15737-2-G03-113

This TER evaluated the fuel canister storage racks to assure they did not create an undue risk to the health and safety of the public. The fuel canister storage racks were utilized to provide storage for the three different types of canisters (fuel, filter, and knockout) which were filled with materials from the TMI Unit 2 reactor core. Storage for a total of 263 canisters was available in the racks which were located in spent fuel pool "A" and the deep end of the fuel transfer canal.

The scope of this TER included the design of the fuel canister storage racks and the activities associated with the installation and use of the racks during defueling. Also included, was a discussion of structural and seismic concerns related to the fuel canister storage racks.

The criticality analyses for the fuel canister storage racks were not within the scope of this Technical Evaluation Report. These analyses were addressed in the Technical Evaluation Report for Defueling Canisters.

Technical Evaluation Report for the Defueling Canisters TER 15737-2-G03-114

This TER addressed the general structural design of the canisters, their operational interface with other systems, flammable gas control considerations, and a criticality evaluation. Based on the information in this report, and other information provided to the NRC by GPU Nuclear, the NRC performed a safety evaluation and approval of the design of the defueling canisters.

Defueling Canister Checklist

This checklist was submitted to the NRC as part of GPU Nuclear's quality assurance review program for the fabrication of the defueling canisters to ensure that the canisters conformed to the design specifications.

TMI-2 Technical Bulletin (TB 86-33) – Dewatering Canisters in Preparation for Offsite Shipment (Changed later to Offsite Shipment of Defueling Canisters)

This TB evolved with the shipping campaign but in general provided data on canister weights before and after dewatering, void volumes, density of contents, payload data, cumulative data on amount of debris shipped and so forth. The TB was issued subsequent to each shipment following data reduction.

TMI-2 Technical Bulletin (TB 86-12) – Defueling Canisters Transfer Log

This TB provided payload data and additional information on defueling canisters and defueling water cleanup system canisters used and transferred to the Fuel Handling Building. The data was used to quantify progress and to track the number of canisters projected to be needed to defuel the reactor.

TMI-2 Technical Bulletin (TB 86-22) – Canister Decontamination Experiment

This TB was used to document various experiments to compare the effectiveness of decontaminating the surface of canisters using various methodologies.

TMI-2 Technical Bulletin (TB 86-34) – Internal Decontamination of Biologically Contaminated Fuel Canisters

This TB provided the results of experiments to evaluate decontaminating (microbially) canisters.

Appendix G

Selected Correspondence
and
Documents of Community Meetings

Appendix G

- James Thompson to John Herrington letter, dated April 2, 1986
- John Herrington to James Thompson letter, dated May 16, 1986
- Don Ofte to J. O. Zane letter, dated June 9, 1989
- Mary L. Walker to Vincent C. Schoemehl, Jr., letter, dated August 13, 1987

Community Meetings

- Ted Trefz to John s. Herrington letter, dated May 5, 1986. S. R. Foley, Jr. to Ted Trefz letter, dated May 30, 1986
- Fred H. Entrikin, Jr. to Terry A. Smith letter, dated June 12, 1986
- Terry A. Smith to Fred H. Entrikin, Jr. letter, dated September 4, 1986
- Resolution 51, City of St. Louis
- S. R. Foley, Jr. to Thomas E. Zych letter, dated August 15, 1986
- Mark H. Pollock to John S. Herrington letter, dated July 22, 1986
- S. R. Foley, Jr. to Mark H. Pollock letter, dated August 12, 1986
- City of Webster Groves Resolution
- T. A. Smith to J. M. Wilson, letter, dated September 18, 1986
- Michael Perry to Terry Smith letter, dated April 30, 1987
- T. A. Smith to P. J. Grant letter, dated June 5, 1987
- T. A. Smith to Peter Mygatt letter, dated April 11, 1988
- T. A. Smith to Peter Mygatt letter, dated May 5, 1988

STATE OF ILLINOIS
OFFICE OF THE GOVERNOR
SPRINGFIELD 62706

JAMES R THOMPSON
Governor

April 2, 1986

The Honorable John S. Herrington
Secretary
U.S. Department of Energy
Washington, D.C. 20585

Dear John:

The State of Illinois has a comprehensive program for assuring the safety of shipments of spent nuclear fuel within the state. Each shipment is inspected as it enters or orginates in Illinois, and is then escorted by trained emergency personnel until it leaves the state or reaches its designation within Illinois. The Illinois Department of Nuclear Safety (IDNS), which coordinates this activity, has inspected and escorted over 300 truck and train shipments of spent fuel since the program was established in 1983.

We have learned that DOE plans to begin shipping through Illinois, by train, damaged spent fuel from Unit 2 of the Three Mile Island (TMI) nuclear power plant. The likelihood of this occurrence has generated much concern among citizen groups and legislators in our state. Consequently, I would like to request your assistance in ensuring that the Illinois inspection and escort program can be efficiently implemented for the DOE's shipment of TMI fuel.

In particular, I would like to request that the DOE inform IDNS at least seven days in advance so that IDNS personnel can inspect the TMI shipments just as they inspect every other shipment through the state. I would like to also request that the DOE require the shipments to travel in a manner that allows state emergency reponse personnel in vehicles to remain in close proximity to the shipments. Also, IDNS suggests that the TMI shipments travel in a dedicated train traveling no more than 35 mph, as commercial shipments are now handled. All of these measures will help assure the public that these shipments pose no greater risk than the other shipments that have come through our state.

I believe it is critical to the success of this effort that the TMI shipments are handled in a manner similar to other shipments through Illinois. I am certain you understand the importance of this matter to our state and thank you in advance for your assistance in ensuring that these shipments are transported without public controversy. You have my personal pledge that all Illinois state personnel will do everything possible to make certain that DOE's schedule is not disrupted.

If we can provide you with further information on this subject, please feel free to contact me or have your staff contact Terry Lash, Director of the IDNS, at 217-546-8100.

Sincerely

James R. Thompson
GOVERNOR

THE SECRETARY OF ENERGY
WASHINGTON, D.C. 20585

MAY 16 1986

Honorable James R. Thompson
Governor of Illinois
Springfield, Illinois 62706

Dear Jim:

Thank you for your letter of April 2, 1986, concerning the planned shipments of spent fuel from Three Mile Island (TMI). I share your strong interest in assuring that this effort is conducted in the safest possible manner.

The Department of Energy (DOE) is shipping the TMI-2 core to its Idaho facility for storage and for examination as part of its research and development program. This program has produced significant information on recovery from a serious reactor accident. Examination of the core materials at DOE's Idaho facility is expected to provide additional data that will greatly benefit future design and regulation of nuclear reactors. This program is of particular importance to States, such as Illinois, having a large number of operating nuclear power plants.

We agree that by incorporating certain features of your inspection program within existing DOE transportation procedures we may allay some of the concerns raised by citizens' groups and the legislature in your State. Accordingly, I propose that staff representatives from the Illinois Department of Nuclear Safety (IDNS) and DOE meet at the origin site to work out specific operational details of both organizations.

The DOE transportation procedures for unclassified spent fuel shipments provide for coordination with State officials along the route and on specific requests for vehicle inspections. Additionally, the DOE physical protection plan includes surveillance service escorts while enroute, as well as in terminals. These surveillance personnel have been thoroughly instructed in emergency response procedures. Concerning your request for State escorts, we are concerned about the safety of IDNS motor vehicle escorts that would parallel moving trains, particularly when they are forced to use secondary roads. This concern is also shared by the Department of Transportation (DOT). However, if the State of Illinois, with the consent of the rail carrier, wishes to provide additional separate vehicle escorts at its own expense, we will coordinate such operations within existing plans.

We have requested that the shipments be transported in commercial thru-train service at normal train speeds. For radioactive materials, this is consistent with the intent of general DOT requirements for shippers to minimize the time in transit. Most of the trackage to be used for these shipments carries a class 4 rating (excellent) which provides additional levels of safety. The Federal Railroad Administration is presently inspecting the entire rail system between origin and destination.

We share a mutual concern for the health and safety of all citizens and the protection of the environment. Please be assured we will continue to exercise the utmost care in our transportation activities.

Yours truly,

John S. Herrington

VINCENT C. SCHOEMEHL, Jr
Mayor

WILLIAM B. HOPE, Jr., Sc.D., M.P.H.
Health Commissioner

July 23, 1986

M E M O R A N D U M

TO: For the Record

FROM: William B. Hope, Jr., Sc.D., M.P.H.
Health Commissioner

SUBJECT: Inspection of Three Mile Island Rail Shipment

The first rail shipment of TMI-2 hazardous waste occurred early on the morning of Tuesday, July 22, 1986. The direct inspection was handled by P.O. Thomas Magnan, P.O. Michael Walsh, St. Louis Metropolitan Police Department, Chief George Jenkerson, Fire Marshal and myself, with assistance from Corporal Charles Pieper, Troop C Missouri Highway Patrol and Mr. Kenneth V. Miller, Administrator, Bureau of Radiological Health, Missouri Department of Health and Mr. Michael Tschetter, Radiological Health Analyst, Bureau of Radiological Health, Missouri Department of Health. Parallel readings and assessments were made by Mr. Miller and Mr. Tschetter using a Model 14C Ludlum GM. Direct measurements were also made by the City team using a Victoreen Model 493 GM and an Eberline Teletector Model 6112B.

The TMI-2 shipment cask arrived on railcar DOX 101 at the Exermont junction at approximately 6:11 a.m. and was moved by an Alton and Southern Railway crew using the Conrail power down to the Alton and Southern railyard arriving at approximately 6:45 a.m. The Cask Car was removed using the Conrail power and repositioned onto the Union Pacific caboose and buffer car. It should be noted that the background readings taken in the track area in front of the Union Pacific buffer car and prior to the arrival of the Cask Car were in the range of 0.05 to 0.07 MR per hour.

Upon arrival of the Conrail shipment and removal of the Cask Car, readings were taken along the northern side of the aft buffer car with results of 0.07 to 0.08 MR per hour.

The orientation of these trains was on an east/west track. The engines were located to the west and the cabooses to the east. The train arrived moving in a westward direction and after the Cask Car was moved to the Union Pacific train, departed in a westward direction.

After the Cask Car was moved into position with the Union Pacific caboose and buffer car, readings were initiated at

Office of the Health Commissioner Suite 420; 634 No. Grand Boulevard

approximately 0700 hours. The first reading made on the north side of the Cask Car was taken through and between the Conrail caboose and aft buffer car. This was done using the extension teletector probe. The resultant readings at approximately the center of the Cask Car were between 0.10 to 0.15 MR per hour.

We then moved in between the trains and using the teletector probe took a series of readings at different locations as follows:

East end of cask overpack; 0.02 to 0.05 MR per hour.
Sweep of north side cask center; 0.10 to 0.19 MR per hour.
North center flap area; 0.21 MR per hour.
Center north side, top of cask; 0.05 to 0.19 MR per hour.
West end cask overpack, center sweep; 0.02 to 0.05 MR per hour.
top center sweep; 0.0 to 0.08 MR per hour.
bottom end sweep; 0.02 to 0.08 MR per hour.

Southside of Cask Car:
Sweep of west end of Cask Car overpack, top to bottom; 0.04 to 0.09 MR per hour.
Sweep center section of Cask Car; 0.05 to 0.20 MR per hour.
Sweep east end Cask Car overpack; 0.02 to 0.09 MR per hour.

Additional readings were taken of various areas of the Cask Car using the Victoreen hand held Model 493 GM. These readings were made at the shroud surface of the cask's coverings. The east end of the cask overpack was checked from standing on top of the rail car and other readings were made from standing beside the car itself. All readings were within the ranges noted above with one exception.

As noted above, an area on the north side of the car in the vicinity of an inspection flap had yielded a high of 0.21 MR per hour. Upon rechecking that area we obtained readings using the times one setting of up to 0.6 MR per hour. Using the times ten setting we obtained readings between 0.6 to 0.9 MR per hour.

It should be noted that all of the above readings were well within Federal guidelines. Federal guidelines allow up to 200 MR per hour at the cask surface and require less than 10 MR per hour at three meters from the sides of the cask.

All readings were completed at 0721 hours on July 22, 1986.

Team two of the City's ALPHA group was located in the Sarpy Union Pacific rail yard just west of the Grand Avenue interlock. Background beta and gamma scans were made of the Union Pacific track area at their location with resultant readings between 0 and 1.0 MR per hour. These scans were made by Doctor Valgard Jonsson, Assistant Health Commissioner, Public Health Laboratory and George Blezard, St. Louis County Health Department using two separate instruments, a Searle Texas Nuclear Corporation Exposure Meter, Model 2592 and an Eberline Model E-500B.

As the train came through the Grand Avenue interlock a sweep from ground level was made of the entire train. Both team members had their instruments at track side close enough to literally touch the cars and detected absolutely no readings from the Cask Car that were above background. In essence, the only radiation measurements detectable in the vicinity of the Cask Car were background radiation.

The above radiation readings document a safe shipment with no detectable radiation levels exceeding the Federally mandated levels.

WBH/jk

cc: Rita Kirkland
Thomas A. Villa
Chief George Jenkerson
Major Joseph Craft
Richard D. Ross
Robert Harmon, M.D.
John Bagby, Ph.D.
Kenneth Miller
Robert Lommler
Terry Smith
Ron Kucera
Richard Rice
Corporal Charles Pieper
Thomas J. Magnan
Michael J. Walsh
Charles G. Copley
Valgard Jonsson, Dr. P.H.
James M. Williams

Department of Energy

Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

June 9, 1989

J. O. Zane, General Manager
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, Idaho 83415-3600

SUBJECT: Approval for the Physical Protection of the TMI-2 Core Debris while in Transit

REFERENCE: Letter L. P. Leach to J. E. Solecki, "Request for Approval for Physical Protection Plan for TMI-2 Shipments", LPL-78-89, June 7, 1989

Dear Mr. Zane:

The physical protection arrangements for the TMI-2 Core Debris shipments submitted in the Reference have been reviewed and are approved. It is clear that the physical protection required by DOE Order 1540.4 is not only being provided now but also has been provided since the start of the shipping campaign. The close cooperation between DOE-HQ, DOE-ID, EG&G, General Public Utilities, CONRAIL, and Union Pacific Railroad Company has clearly had a positive effect on assuring the required physical protection of this unclassified nuclear material while in transit. It is important for this to continue.

Sincerely,

S B Millar
for Don Ofte
Manager

cc: D. F. Giessing, DOE-NE
N. P. Klug, DOE-NE
L. H. Harmon, DOE-DP
W. A. Franz, EG&G
L. P. Leach, EG&G

Island Nuclear Station, Unit 2 (NUREG-0683). It should be noted that NUREG-0683 addressed the impacts related to the transport of the TMI spent fuel by rail in Appendix U.

Based on our review, it is the Department's judgment that the potential environmental impacts of these fuel shipments have been adequately considered in existing NEPA documents which are still valid, and that the impacts are clearly insignificant. Therefore, the preparation of an EIS is not necessary.

Moreover, the shipping casks used to transport the TMI spent fuel provide double containment of the fuel to avoid any release to the environment. The NRC Certificate of Compliance (a shipping cask license) was obtained for these casks, and the casks were extensively tested under accident conditions to ensure they would retain their integrity in the case of shipping accidents.

To date we have conducted nine successful shipments, which are about one-third of the planned shipments. I can assure you that the Department will continue to conduct these activities in a safe and environmentally sound manner.

If you have any further questions on this matter, please do not hesitate to contact us.

Yours truly,

Mary L. Walker
Assistant Secretary
Environment, Safety and Health

..arshall

. Avenue
.. Box 295
rshall Illinois 62441
-526-2112

TED TREFZ
Mayor

● STEVE CALHOUN
Office Manager

● GEORGE O SMITH
Supt of Utility

● RAYMOND MILLER
Supt of Gas

May 5, 1986

The Honorable John S. Herrington
Secretary
U. S. Department of Energy
Washington, D.C. 20585

Dear Sir:

The City of Marshall along with several other communities in Clark County, went to a meeting concerning the shipping of the spent nuclear fuel from three-mile-island. Although we realize that it has to be shipped, we are concerned as everyone else is with the safety.

We realize that you can't notify the public of when the waste is coming through, but we also feel that the same precautions that apply to commercial shipments through the state of Illinois should also be in effect for shipments made by the Federal Government.

Thanking you in advance for our concern,

Sincerely,

Ted Trefz
Mayor

TT/lh

cc: Mike Weaver

Department of Energy
Washington, DC 20585

MAY 30 1986

Honorable Ted Trefz
Mayor of The City of Marshall
Marshall, Illinois 62441

Dear Mayor Trefz:

Your letter of May 5, 1986, to Secretary Herrington about the Three-Mile Island waste shipments has been referred to my office for reply.

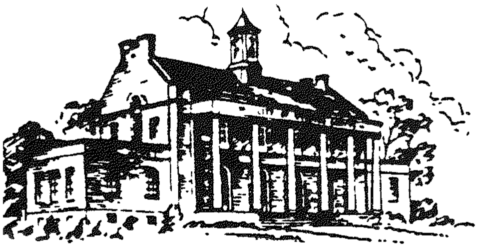
The Department of Energy (DOE) transportation procedures for unclassified spent fuel shipments provide for coordination with State officials on the route and on specific requests for vehicle inspections. In a recent communication to Governor Thompson, Secretary Herrington proposed that DOE staff and representatives from the Illinois Department of Nuclear Safety meet to discuss specific operational details for these shipments.

In general, the precautions taken by the Federal Government for unclassified spent fuel shipments are similar to those taken for commercial shipments.

We share a mutual concern for the health and safety of all citizens and the protection of the environment. Please be assured we will continue to exercise the utmost care in our transportation activities.

Sincerely,

S. R. FoTey, Jr.
Assistant Secretary
for Defense Programs



City of Webster Groves, Missouri

Office of the Fire Chief

June 12, 1986

Mr. Terry A. Smith
EG&G Idaho, Inc.
P. O. Box 1625
Idaho Falls, ID 83415

Dear Mr. Smith:

On Wednesday, June 11, I met with Mr. Richard Ross, Director of Emergency Management for the State of Missouri, in Jefferson City, for the purpose of discussing the shipments of radioactive material from TMI through the City of Webster Groves.

Prior to my meeting with Mr. Ross, Mayor Sheffield and I met with a group of concerned citizens from Webster Groves and University City. After discussing with Mr. Ross all of the safety precautions that have been taken by the various agencies involved, he suggested that I send to you the attached list of questions that were presented to us.

I would appreciate your immediate consideration relative to this list, as quite naturally, both we as City officials and our citizenry are very concerned about the shipments.

Thanking you in advance for your cooperation, I am,

Very sincerely,

Fred H. Entrikin, Jr.
Fire Chief
Director of Civil Preparedness

FHEjr/kr
encl.

cc: Mrs. Glenn Sheffield, Mayor
Joseph B. Morrison, City Manager

Dear Chief Antrekein and Mr. Bussey,

The following are the questions that we would like to have you pose in our stead to the state representatives that are going to Three Mile Island.

We would like a report from the Department of Energy demonstrating that this route is the safest way to go.

What is the least populated train route between Pennsylvania and Idaho Falls? Why not use it? If it does not meet safety standards, why not wait until it is brought up to standards? What comprises the safety of the routes?

What tests are being done on the material from Three Mile Island at Idaho Falls?

Why is it necessary to ship all the fuel rods, etc., from Three Mile Island for these tests? Would one shipment suffice?

What is the ultimate destination of this material after Idaho Falls?

Why haven't tests been done on full-sized casks under realistic conditions (internal pressure and temperatures that would be present with melted irradiated fuel rods)?

Has an independent test of casks and cannisters been done? What are the results, if so.

Is our Fire Department's equipment adequate for a nuclear accident in our community?

In the event of a nuclear accident, what kind of liability does Union Pacific have for property and health damage?

Will there be armed guards on board the trains?

In the event of a nuclear accident where the cask is ruptured, how wide an area would be effected? How long would it take for damage to spread? What kind of health damage could occur if the accident were to occur in Webster Groves?

Thank you again for taking the time to meet with us.

I will expect answers to these questions by Friday, June 13 if possible. In addition, please send me copies of your correspondence with the G.A.O. and the O.T.A.

Sincerely, Cheryl K. Wilke
Cheryl K. Wilke
25 So Maple

We as,concerned citizens,met with Mayor Glenn Sheffield and other city officials of Webster Groves on,June 5, 1986, to discuss the proposed transport of radioactive waste through our city. We asked that the following questions be addressed by our elected officials

1. Has the Department of Energy demonstrated that this is the <u>safest</u> route?
2. What comprises the safety of the routes?(population density, condition of the tracks, etc.) Will this train be a special use train or a mixed train on which both radioactive and other hazardous materials are carried? Wil this train be required to travel at a special reduced speed?
3. What proposed tests are to be performed on the radioactive materials from Three Mile Island at Idaho Falls?
4. What is the ultimate destination of the radioactive material after Idaho Falls? Could it come back through St.Louis to Tennessee, for example?
5. Why is it necessary to ship all of the radioactive fuel rods when there is on-site storage at Three Mile Island? Would one shipment suffice?
6. Since the canisters were designed and fabricated by Babcock and Wilcox(designers of the Three Mile Island nuclear reactor) has an <u>independent test</u> of these canisters been done under realistic conditions of internal pressure, temperature, and radioactivity that would be present with melted fuel rods? If so, what are the results? Have similar <u>independent tests</u> been performed on the casks designed by Nuclear Packaging, Inc. that will hold the canisters containing the irradiated fuel rods?
7. Are our Webster Groves Police and Fire Departments trained and equipped to handle a nuclear accident in our community? Do we have respirators and shielded clothing, etc.
8. In the event of a nuclear accident where the cask is ruptured, how wide an area would be affected? What kind of health damage could occur in Webster Groves? Have the city of Webster Groves and the Federal government established an evacuation plan?
9. Will city officials be proveded with a time table for all shipments or will they be notified only on a "need to know" basis?
10. In the event of a nuclear accident, what kind of liability does Union Pacific have for property and health damage? If Union Pacific is not liable, who will bear the responsibility for property and health damage?

Since the Department of Energy and the Nuclear Regulatory Commission are the two largest proponets of nuclear energy as well as the only regulatory agencies for nuclear energy, we as citizens of Webster Groves urge our elected officials to insist that the General Accounting Office provide an independent and objective evaluation of this operation. We also urge our officials to insist on an Environmental Impact Statement as required by the National Environmental Policy Act of 1969. If you share our concerns, write your local, county, state and federal representatives.

Sincerely,

Christa Wissler
and

Dotty DeLassus

cc: Globe Democrat
Journal Newspapers
St. Louis Post Dispatch
St. Louis Suburban Newspapers
Webster Kirkwood Times
Sentinel Newspapers
The Brentwood Pulse
The Washington -Missourian
KMOX_TV
KSDK TV
Channel 2
KPLR TV
Thomas Eagleton
John Danforth
Richard A. Gephardt
William Clay
Senator Frank Bild
Congresswoman Marion Cairns
Mrs. Ellen Conant
H. C. Milford

Mayor Vincent Schoemehl
Alderman Timothy Dee
Alderwoman Phyllis Young
Governor John Ashcroft
Lt. Governor Harriet Woods
City Of Kirkwood
City Of Maplewood
City of Valley Park
City of Eureka

EG&G Idaho Inc
PO Box 88, Middletown, PA 17057

September 4, 1986

Fred H. Entrikin, Jr.
Fire Chief
6 South Elm Avenue
City of Webster Groves, MO 63119

REQUEST FOR TMI-2 FUEL SHIPPING INFORMATION - TAS-17-86

Ref: F. H. Entrikin ltr to T. A. Smith requesting information on the TMI-2 Fuel Shipping Program, June 12, 1986

Dear Chief Entrikin:

The reference letter included an attachment that listed 11 sets of questions from a group of concerned citizens from Webster Groves and University City. Your letter requested responses to those questions.

Question 1. We would like a report from the Department of Energy demonstrating that this route is the safest way to go.

Response 1. The safety of the public always has been and continues to be the highest priority in the Three Mile Island Unit 2 (TMI-2) fuel debris transport program. The safety of the public is ensured first and foremost by the strong leaktight cask in which the material is shipped. Typical of other spent fuel shipping casks, the NuPac 125B for the TMI-2 core material is certified by the Nuclear Regulatory Commission (NRC) and designed to withstand a series of hypothetical accident conditions which simulate a very severe transportation accident. To clearly and unquestionably demonstrate the ability of the TMI-2 cask to withstand severe impacts during transportation accidents, a scale model was built and drop-tested in a program which was not required by 10CFR71 regulations but which does provide an easily understood, visual record of the durability of the TMI-2 cask.

Another element in the Department of Energy (DOE) plan to safely transport the TMI-2 fuel debris is to ensure that the best tracks and shortest transport time reasonably available are used. These criteria are in accordance with Department of Transportation (DOT) guidelines to minimize time in transit, use excellent track, avoid high densities when possible, and accomplish the shipments with the fewest switches between rail carriers. In following these guidelines, the rail carriers and the DOE selected a route that accomplishes the shipments in four-five days, uses the highest quality track available and involves only one carrier change, between Conrail and Union Pacific in East St. Louis, Illinois. Although routing is thoroughly considered in transferring radioactive materials, it is only a secondary safety factor, with primary safety being provided to the public and the environment by cask integrity.

Each segment of transportation for the TMI-2 shipments will comply with applicable regulations of the DOT, which regulates shipments under the authority of the Hazardous Materials

Transportation Act. DOT has established extensive safety regulations for radioactive materials transport, including, but not limited to, requirements for inspections, packaging, monitoring, training, security and reporting. In the more than 40 years of transporting radioactive materials across the United States, an exemplary record of safety has been achieved. Although there is public apprehension about shipping spent fuel, there has never been an injury or death attributable to radiation as a result of an accident involving transportation of radioactive materials.

As a further commitment to public safety, the DOE selected rail carriers with extensive experience in handling hazardous materials. The Union Pacific Railroad hauls more hazardous material than any other land-based carrier in the U.S., and Conrail is also a major carrier of such materials. Both Conrail and Union Pacific have maintained high safety records. Union Pacific won the coveted 1985 Harriman Safety Award, which honors the rail carrier with the top safety record in the industry. In the last 20 years, Union Pacific has won this award 17 times, a record of achievement which demonstrates Union Pacific's commitment to safety.

As further safety precautions: a) the Federal Railroad Administration (FRA) has inspected the entire route used for these shipments and the rail carriers conduct routine inspections to ensure the high quality of the tracks; b) the TMI-2 shipments are routinely inspected before shipment by DOE, NRC, DOT and FRA officials; c) the railcars are maintained each trip through a maintenance contract with Union Pacific; d) some of the states are monitoring shipments en route in support of local emergency response efforts; and e) radiological and vehicular inspections are conducted at the destination facility at the Idaho National Engineering Laboratory (INEL).

Question 2. What is the least populated train route between Pennsylvania and Idaho Falls? Why not use it? If it does not meet safety standards, why not wait until it is brought up to standards? What comprises the safety of the routes?

Response 2. It should be noted that the safety of the public is not solely determined by how many people are along the route, but rather by first having a safe shipping package and second by getting that package from TMI to the INEL as safely and as quickly as possible. To achieve the second objective, the highest quality track and the shortest travel time are used. A principal reason for not using the least populated routes is to avoid using lower quality track on less populated routes and experiencing delays in switching trains to get onto and off of those sections of track.

The suggestion of upgrading lower quality track to a higher safety standard (higher track classification) is a decision that would have to be made exclusively by the railroads since they own the tracks.However, even if track were upgraded, routing decisions would have to consider the factor of longer travel time due to the potential of a circuitous route or excessive switching.

Question 3. What tests are being done on the material from Three Mile Island at Idaho Falls?

Response 3. The core examination work being performed in the DOE program is outlined in two documents that are enclosed: EGG-TMI-7121 - TMI-2 Accident Evaluation Program, Sample Acquisition and Examination Plan, Executive Summary; and EGG-TMI-7048 - TMI-2 Accident Evaluation Program.

A brochure also is enclosed describing the hot cell facilities at the INEL that will be used for a large part of the core examinations specified in the DOE program.

Question 4. Why is it necessary to ship all the fuel rods, etc., from Three Mile Island for these tests? Would one shipment suffice?

Response 4. The Summary to the Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from the March 28, 1979 Accident at Three Mile Island Nuclear Station Unit 2, NUREG-0683, Volume 1, states in part: "The location, geology, and hydrology of Three Mile Island are among the factors that do not meet current criteria for a safe long-term waste disposal facility. Removing the damaged fuel and radioactive waste to suitable storage sites is the only reliable means for eliminating the risk of widespread uncontrolled contamination of the environment by the accident wastes." A Memorandum of Understanding between the NRC and the DOE concerning the removal and disposition of solid nuclear wastes from the cleanup of TMI-2 was first finalized in July 1981 and subsequently revised to reflect DOE taking the core for its research value in March 1982. Following the NRC decision to have the core material removed from TMI, the DOE selected the INEL as the most suitable location to study the material. This decision was based upon the INEL's vast experience in both analyzing and handling spent nuclear fuel and nuclear waste.

The research value of the TMI-2 core material is substantial. In an effort to maximize the amount of technical and scientific information gained from the accident at TMI, DOE has assumed custody of highly radioactive waste materials from TMI, such as the EPICOR and Submerged Deminerlizer System wastes and transported those materials to its national research facilities in the states of Idaho and Washington. There, scientists and engineers used those materials in waste immobilization research and development programs to obtain the most information possible in preparation of those materials for final disposition. The same type of strategy is planned for the TMI-2 core material. DOE's experience in studying previously obtained small grab samples of core materials from TMI-2 has shown it will be advantageous to have all the materials from the core to be able to obtain future samples from strategic locations in the core. As continuing research identifies new and additional preferences for core samples, it will be more efficient to have ready access to core materials stored where the examination and studies will be conducted.

Because of the amount and nature of the TMI-2 fuel material, between 35-40 shipments will be required. This number of shipments is not precedent setting for TMI-2 wastes. Previously 50 shipments to the INEL were required for the EPICOR wastes and following processing 46 shipments of EPICOR wastes were sent from the INEL to the U.S. Ecology Commercial Disposal Site in the State of Washington.

Question 5. What is the ultimate destination of this material after Idaho Falls?

Response 5. The TMI-2 fuel debris will be stored at the INEL and used for research until a national high level waste repository opens. At that time the material would be processed as necessary to meet repository acceptance criteria and shipped for ultimate disposal. The TMI-2 fuel debris canisters are designed for 30 years of safe storage in the INEL facility.

Question 6. Why haven't tests been done on full-sized casks under realistic conditions (internal pressure and temperatures that would be present with melted irradiated fuel rods)?

Question 7. Has an independent test of casks and canisters been done? What are the results, if so?

Response 6&7 The DOE and the NRC concluded that full-scale drop testing of the canisters should be performed to verify the integrity of the canisters under hypothetical accident conditions. The canister tests were performed with the contents of the canisters simulated (weight and the material). These tests were performed independently at the DOE Oak Ridge National Laboratory. The drop test analyses were used to verify that the canisters would maintain their integrity during worst case accidents.

Full-scale cask testing is not required. There have been tests on full-sized casks which were performed under realistic conditions of temperature and pressure and well-simulated contents although not with actual spent fuel assemblies. Data from these tests were used in design and analyses of the TMI-2 cask. The independent cask tests for the TMI-2 cask were done at Sandia National Laboratory on a one-quarter scale model under very severe conditions. Drop tests were performed with the cask "frozen" at -20 degrees Fahrenheit to simulate severe temperature regimes. Most spent fuel shipments have fuel rods with internal pressure that generate quantities of decay heat, but the TMI-2 cask was designed specifically for the TMI-2 debris. The condition of the TMI-2 fuel debris is such that the damage from the accident has resulted in failure of the fuel cladding which released the internal pressure in each rod. Also, the temperature of the TMI-2 fuel debris will be low since the energy generated from the decay or radionuclides in this debris is not significant for several reason; i.e., the short operating period of less than 100 full power days for the TMI-2 core before the accident did not allow buildup of fission products, there has been a 7.5-year time for radioactivity decay since 1979, the gaseous fission products were released into the TMI-2 containment building during the accident and a significant "wash out" of fission products from the TMI-2 core debris occurred when the fuel rod cladding failed and water reached the fuel pellets.

Question 8. Is our Fire Department's equipment adequate for a nuclear accident in our community?

Response 8. The DOE has established emergency response plans incorporating eight regionally located offices having trained radiological emergency response teams capable of mobilizing within two hours and arriving at an accident scene within six-eight hours. Nationwide, 26 DOE Radiological Assistance Teams are available. Additionally, an escort thoroughly trained in emergency response accompanies TMI shipments. The principal function of Webster Groves emergency personnel would be to isolate the situation until assistance arrives. If specific training is desired, the DOE provides funds in conjunction with the Federal Emergency Management Agency (FEMA) to conduct the appropriate training of emergency response personnel to handle off-normal radiological instances.

Question 9. In the event of a nuclear accident, what kind of liability does Union Pacific have for property and health damage?

Response 9. In the event of a nuclear transportation incident there is a broad umbrella of financial protection for public liability through the Price-Anderson Act (42 USC section 2014m 2210).

Protection would be provided for liability resulting from a nuclear incident arising out of the transportation of spent nuclear fuel. This protection is afforded not only to the carrier, but also any other person or entity who might be liable to the public for damages resulting from a nuclear incident.

Question 10. Will there be armed guards on board the trains?

Response 10. The DOE does not require armed guards for the shipments. However, the rail carriers have elected to provide security personnel who will either be on the trains or readily available.

Question 11. In the event of a nuclear accident where the cask is ruptured, how wide an area would be affected? How long would it take for damage to spread? What kind of health damage could occur if the accident were to occur in Webster Groves?

Response 11. With the foregoing discussions in mind, it should be clear that the NuPac 125B shipping cask is designed to survive rail accidents. A breach of cask integrity during such accidents is considered extremely remote. But assuming "the cask is ruptured" as stated in the question, there is very little driving force within the package to release active particulate and/or gases to the environment and the area of concern would be very localized. Normal and prudent accident isolation and security measures would protect local citizens from potential nuclear hazards and health considerations. An exclusion area for onlookers of several hundred yards has been suggested by some experts as being conservative; this is not to suggest that those personnel required to isolate the accident should not enter the area; it is fully expected that the cask could be approached quite closely without adverse effects. but prudence should prevail until radiological assistance arrives. The rail carriers would work with both state and local officials in the event of an accident and Federal assistance would be readily provided if required.

Thank you for your patience in waiting for responses to these questions. Please call or write if I might be of further assistance.

Sincerely yours

Terry A. Smith
Public Information Office

bf

Enclosures:
As Stated

RESOLUTION NUMBER 51

WHEREAS, the Committee on Health and Welfare of the St. Louis Board of Aldermen has conducted a hearing regarding the federal government's proposal to send at least forty (40) 100-ton shipments of Three Mile Island's melted fuel and other high-level radioactive waste by train from Pennsylavnia westward to Idaho, passing through the City of St. Louis, over approximately the next three years; and

WHEREAS, testimony has indicated that the Departments of Health, Disaster Operations, Public Safety and Streets have taken all available precautions within their power, and

WHEREAS, a derailment, fire, collision or other accident could disperse permanently toxic radioactive steam, gases and particulate matter into our neighborhoods and beyond--causing the potential of death, life-shortening illnesses, and birth and genetic defects, as well as the destruction of property and property values; and

WHEREAS, only minimal testing has been performed of the casks and canisters designed for shipping this reactor core debris; and

WHEREAS, an average medical or academic research laboratory experiment encompasses only a tiny fraction of one curie of radioactivity, as compared with an estimated total of at least 80,000 curies per each TMI fuel cask (one cask per shipment); and

WHEREAS, state and local emergency personnel are neither adequately trained or equipped to handle a major nuclear transport accident; and

THEREFORE BE IT RESOLVED that this Honorable Board of Aldermen initiate immediate research to strengthen Ordinances concerning transportation of radioactive material and other hazardous material through the City of St. Louis, and that this Board strongly urge the State of Missouri to establish a radiological/hazardous materials response team (as in the State of Illinois), and request an independent investigation and appraisal under the National Environmental Policy Act (NEPA) of the comparative environmental, health, safety and fiscal risks of this proposed transcontinental shipping project versus alternatives, and request that an adequate determination of liability assessment be made--before deciding to proceed.

Introduced this the 11th day of July, 1986 by:

HEALTH AND WELFARE COMMITTEE:

Alderman Steven C. Roberts, 20th Ward - Chairman
Alderman Phyllis Young, 7th Ward
Alderman Geraldine Osborn, 15th Ward
Alderman Timothy J. Dee, 17th Ward
Alderman Mary Ross, 5th Ward
Alderman Daisy McFowland, 4th Ward
Alderman Wayman Smith, 26th Ward

ATTEST

Fred Steffen
Clerk, Board of Aldermen

Thomas E. Zych
President, Board of Aldermen

AUG 15 1986

Mr. Thomas E. Zych
President, Board of Aldermen
City of St. Louis
City Hall, Room 230
1200 Market
St. Louis, MO 63102

Dear Mr. Zych:

Thank you for sending Secretary of Energy John S. Herrington a copy of your Resolution No. 51 introduced July 11, 1986, regarding the shipment of spent nuclear fuel from the Three-Mile Island (TMI) site in Pennsylvania to Idaho Falls, Idaho. As the Department of Energy (DOE) organization responsible for the transportation of radioactive materials, your Resolution was referred to me for a reply.

We appreciate the interest of the Board of Aldermen in this matter and understand the concerns which likely prompted enacting Resolution No. 51. We share a mutual concern for the health and safety of all citizens and protection of the environment. Please be assured we will continue to exercise the utmost care in our transportation activities.

Your Resolution mentions concerns about local emergency response capabilities. DOE has established emergency response plans incorporating eight regionally located offices with trained radiological emergency response teams. These teams are capable of mobilizing within 2 hours and arriving at an accident scene within 6-8 hours. Nationwide, 28 DOE Radiological Assistance Teams are available. Additionally, an escort thoroughly trained in emergency response accompanies the TMI shipments at all times.

The issues you raise have been asked frequently and the Department has indeed given them careful consideration. I have enclosed a fact sheet addressing those concerns. I hope this information will be helpful in reviewing the concerns in your Resolution.

Again, we are pleased to respond to your Resolution.

Sincerely,

(signed)

S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

Enclosure

August 4, 1986

Summary of Three-Mile Island (TMI) Transportation, Environmental, and Programmatic Requirements

Environmental Review:

The National Environmental Policy Act of 1970 requires Federal agencies to consider the environmental effects of proposed major Federal actions. The environmental effects of this program were considered and the Department concluded, as is the case for other current spent fuel shipments, there would be no significant environmental impact. The impacts of the TMI shipment program are bounded by those described in the Nuclear Regulatory Commission's (NRC) report NUREG-0170, Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes. The Commission concluded the environmental impacts of normal transportation of radioactive material and the risks of accidents involving radioactive materials shipments are sufficiently small to allow shipping by all modes. Further, the Commission stated transportation under present regulations provides adequate safety to the public. The probable risks evaluated in that study remain the same today and continue to provide justification for package testing standards issued by the NRC.

This environmental impact statement was also used by the Department of Transportation (DOT) and upheld by the courts to support a uniform national routing regulation for transporting radioactive materials, Highway Routing of Radioactive Materials, Docket No. HM-164. The DOT concurred with the NRC that the transportation of radioactive materials is a low-risk activity by any level of comparison.

A specific environmental impact statement was also issued by the NRC related to the programmatic effects of handling the TMI spent fuel, Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979, Accident--Three-Mile Island Nuclear Station, Unit 2, NUREG-0683. This study included review of the transportation aspects supporting removal of the fuel. We have enclosed an abstract from this environmental impact statement for your review.

TMI Fuel Analysis:

The TMI spent fuel being transported is damaged core material from the TMI-2 reactor. The Department of Energy (DOE) is shipping this material to its Idaho facility for storage and examination as part of its research and development program. This program has produced significant information on recovery from a serious reactor accident. Examination of core materials at DOE's Idaho facility is expected to provide additional data that will greatly benefit future design and regulation of nuclear reactors.

Cleanup of TMI is a complex task and much is being learned about recovery from such an incident. We expect to learn even more as we closely examine the core material. More importantly, we want to make sure TMI does not become a long-term waste disposal site.

Transportation Aspects:

The decision to transport the TMI core material was made very carefully. Our main concern is always the health and safety of all citizens and protection of the environment. Rail was chosen as the mode of transportation in order to reduce the number of shipments. We plan 35-40 rail shipments. Two-hundred fifty truck shipments would have been needed.

In compliance with the DOT guidelines for routing large quantities of radioactive materials so that time in transit is minimized, these rail shipments are conducted over shortest distances on higher quality mainline tracks. We avoid population centers where possible.

As a further safety precaution, the Federal Railroad Administration (FRA) has inspected the entire route the shipments use. In addition, the rail carriers routinely inspect the tracks to ensure their quality. TMI shipments are routinely inspected before shipment by the DOE, NRC, DOT, and FRA officials. Similar radiological and vehicular inspections are conducted at the destination facility in Idaho. Finally, specific States are monitoring shipments en route in support of local emergency response efforts.

Each segment of transportation for the TMI shipments will comply with applicable regulations of the DOT under the authority of the Hazardous Materials Transportation Act. DOT has established extensive safety regulations for radioactive materials transport including, but not limited to, requirements for inspections, packaging, monitoring, training, security, and reporting.

In the more than 40 years of transporting radioactive materials across the United States, we have achieved an exemplary record of safety. Although there is public apprehension about shipping spent fuel, there has never been an injury or death attributable to radiation as a result of an accident involving its transportation.

Transportation Cask Safety:

The NRC has licensed the two casks being used for TMI shipments. Also, new heavy-duty railcars are being used which have been approved by the Association of American Railroads.

Unlike other hazardous materials, the radioactive materials shipping container provides the primary safety factor in transporting materials, assuring protection to the public, transport workers, and the environment. The casks used by the DOE for spent fuel shipments are designed to ensure the contents are safely contained even in the event of a severe accident. Rigorous design, analysis, and testing programs have repetitively demonstrated cask survival even when subjected to fire, collision, puncture, or water immersion scenarios beyond what is experienced in "normal" transport accidents.

Liability for an Accident:

In the event of a nuclear transportation incident (irrespective of how remote such a possibility may be) there is a broad umbrella of financial protection for public liability through the Price-Anderson Act (42 USC sections 2014, 2210). Protection would be provided for liability resulting from a nuclear incident arising out of the transportation of spent nuclear fuel. This protection is afforded not only to the carrier, but also any other person or entity who might be liable to the public for damages resulting from a nuclear incident.

Enclosure

Mark H. Pollock
Member, Council
City of Pittsburgh

Chairman, Committee on
Housing, Planning and
Development

Room 510
City-County Building
Pittsburgh, PA. 15219
(412) 255-2130

July 22, 1986

John S. Herrington, Secretary
Department of Energy
Forrestal Building
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Secretary Herrington:

You were recently sent a Resolution which had been unanimously passed by Pittsburgh City Council on July 14, 1986. My purpose in writing is to make certain that the intent of this Resolution is clear.

As you know, the Department of Energy intends to transport radioactive, nuclear waste from Three Mile Island to Idaho. The proposed route passes directly through the major metropolitan area of Pittsburgh. Indeed, it goes through the most populous residential section in the heart of the central business district. Council objects strenuously to this plan.

It is my understanding that the first load of this material was already shipped and the Pittsburgh route was used. Further, our Public Safety Department was not informed so that safety procedures could be implemented. This is totally unsatisfactory.

I would appreciate it if you would examine this situation so as to determine an alternate route which would avoid the City of Pittsburgh. As this material has been in existence for over 7 years and the transporting of it will take 2 to 3 years, clearly time is not of the essence.

It should also be noted that elected officials from many municipalities neighboring Pittsburgh are similarly concerned about and opposed to the existing plan. Surely, another route could be found which avoids metropolitan areas.

Thank you for your kind attention to this matter. I hope you agree with me that the physical and psychological health of our residents should be of the utmost concern.

Yours very truly,

Mark H. Pollock

MHP:msy

R E S O L U T I O N

WHEREAS, the Department of Energy and GPU Nuclear Corporation have announced that radioactive fuel fragments and debris from the Three Mile Island Unit 2 Nuclear Reactor will be shipped by rail car through the Pittsburgh area later this month; and,

WHEREAS, the psychological and physical health of the people of the City of Pittsburgh are threatened by the presence of these radioactive fuel fragments and debris in or around Pittsburgh.

NOW THEREFORE BE IT RESOLVED, that the Council of the City of Pittsburgh does hereby respectfully request that the Department of Energy and GPU Nuclear Corporation redirect the route of said radioactive material so that it does not go through the major metropolitan area of Pittsburgh or, in the alternative, that they inform the Director of the City of Pittsburgh's Department of Public Safety as to the date, time, and route of the rail car carrying said radioactive material so that he can take appropriate action to safeguard the health and safety of the people of the City of Pittsburgh.

PRESENTED BY COUNCILMAN MARK H. POLLOCK

AUG 12 1986

Mr. Mark H. Pollock
Member, Council
City of Pittsburgh
Room 510, City-County Building
Pittsburgh, PA 15219

Dear Mr. Pollock:

Thank you for your letter of July 22, 1986, to Secretary of Energy John S. Herrington regarding the shipment of spent fuel from the Three-Mile Island (TMI) nuclear reactor. As the Department of Energy (DOE) organization responsible for transportation of radioactive materials, your letter was sent to me for a reply.

We appreciate the interest of the City Council in this matter and understand the concerns prompting the resolution you sent us. We share a mutual concern for the health and safety of all citizens and protection of the environment. Please be assured we use extreme care in our transportation activities.

Route selection was based on the Department of Transportation guidelines recommending using the best route available and minimizing the time in transit. In conjunction with the rail carriers, the DOE selected a route that uses the highest quality track available and minimizes time in transit. More direct routes avoid diversions and excessive switching delays. While population density is a factor we analyze in route selection, it is sometimes necessary to ship through large metropolitan areas like Pittsburgh because the highest quality track passes through these areas. Additionally, the Federal Railroad Administration will inspect the entire route to assure its safety.

Although routing is a factor in the safe transportation of spent fuel, the most important safety consideration is the package. The Department is using special spent fuel casks certified by the Nuclear Regulatory Commission specifically designed to ensure the contents are safely contained even in a severe accident. I have enclosed a fact sheet that addresses in greater detail the concerns you raise.

You request the Pittsburgh Department of Public Safety be notified of each shipment. We have discussed this matter with the Pennsylvania Emergency Management Agency (PEMA), which receives information directly from the DOE. PEMA has the authority to provide this information, where appropriate, to assist local emergency response planning. We suggest you contact Mr. John Patton, Director of PEMA. If you have further questions about the shipping plans, please contact the DOE's TMI site office at (717) 948-1062.

I appreciate the opportunity to respond to your letter.

Sincerely,

(signed)

S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

August 4, 1986

Summary of Three-Mile Island (TMI) Transportation, Environmental, and Programmatic Requirements

Environmental Review:

The National Environmental Policy Act of 1970 requires Federal agencies to consider the environmental effects of proposed major Federal actions. The environmental effects of this program were considered and the Department concluded, as is the case for other current spent fuel shipments, there would be no significant environmental impact. The impacts of the TMI shipment program are bounded by those described in the Nuclear Regulatory Commission's (NRC) report NUREG-0170, Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes. The Commission concluded the environmental impacts of normal transportation of radioactive material and the risks of accidents involving radioactive materials shipments are sufficiently small to allow shipping by all modes. Further, the Commission stated transportation under present regulations provides adequate safety to the public. The probable risks evaluated in that study remain the same today and continue to provide justification for package testing standards issued by the NRC.

This environmental impact statement was also used by the Department of Transportation (DOT) and upheld by the courts to support a uniform national routing regulation for transporting radioactive materials, Highway Routing of Radioactive Materials, Docket No. HM-164. The DOT concurred with the NRC that the transportation of radioactive materials is a low-risk activity by any level of comparison.

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Cleanup of TMI is a complex task and much is being learned about recovery from such an incident. We expect to learn even more as we closely examine the core material. More importantly, we want to make sure TMI does not become a long-term waste disposal site.

Transportation Aspects:

The decision to transport the TMI core material was made very carefully. Our main concern is always the health and safety of all citizens and protection of the environment. Rail was chosen as the mode of transportation in order to reduce the number of shipments. We plan 35-40 rail shipments. Two-hundred fifty truck shipments would have been needed.

In compliance with the DOT guidelines for routing large quantities of radioactive materials so that time in transit is minimized, these rail shipments are conducted over shortest distances on higher quality mainline tracks. We avoid population centers where possible.

As a further safety precaution, the Federal Railroad Administration (FRA) has inspected the entire route the shipments use. In addition, the rail carriers routinely inspect the tracks to ensure their quality. TMI shipments are routinely inspected before shipment by the DOE, NRC, DOT, and FRA officials. Similar radiological and vehicular inspections are conducted at the destination facility in Idaho. Finally, specific States are monitoring shipments en route in support of local emergency response efforts.

Each segment of transportation for the TMI shipments will comply with applicable regulations of the DOT under the authority of the Hazardous Materials Transportation Act. DOT has established extensive safety regulations for radioactive materials transport including, but not limited to, requirements for inspections, packaging, monitoring, training, security, and reporting.

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Transportation Cask Safety:

The NRC has licensed the two casks being used for TMI shipments. Also, new heavy-duty railcars are being used which have been approved by the Association of American Railroads.

Unlike other hazardous materials, the radioactive materials shipping container provides the primary safety factor in transporting materials, assuring protection to the public, transport workers, and the environment. The casks used by the DOE for spent fuel shipments are designed to ensure the contents are safely contained even in the event of a severe accident. Rigorous design, analysis, and testing programs have repetitively demonstrated cask survival even when subjected to fire, collision, puncture, or water immersion scenarios beyond what is experienced in "normal" transport accidents.

Liability for an Accident:

In the event of a nuclear transportation incident (irrespective of how remote such a possibility may be) there is a broad umbrella of financial protection for public liability through the Price-Anderson Act (42 USC sections 2014, 2210). Protection would be provided for liability resulting from a nuclear incident arising out of the transportation of spent nuclear fuel. This protection is afforded not only to the carrier, but also any other person or entity who might be liable to the public for damages resulting from a nuclear incident.

Enclosure

RESOLUTION

WHEREAS, the City Council has been advised of the federal government's intention over approximately the next three years to transport by train at least forty (40) 100-ton shipments of Three Mile Island's melted fuel and other high-level radioactive waste from Pennsylvania to Idaho, such shipments to pass through the Metropolitan St. Louis area, including the City of Webster Groves; and

WHEREAS, the City Council, Fire Department, Police Department, and Civil Preparedness Coordinator have attempted to inform themselves of the procedures to be used in these shipments and have taken all available precautions within their power, and

WHEREAS, in spite of assurances by responsible federal and state officials that the shipment procedures are safe, there remain questions still unanswered regarding these procedures and it is clear that the shipment of nuclear waste materials through the City of Webster Groves represents an undesirable risk in the event of a catastrophic and unpredictable railway accident; and

WHEREAS, the City of Webster Groves is without sufficient emergency personnel, equipment and financial resources to safeguard its residents in the event of a major nuclear transport accident;

NOW, THEREFORE, BE IT RESOLVED, that the City Council of the City of Webster Groves strongly urges the State of Missouri's

Department of Public Safety, with the assistance of Missouri's Congressional delegation: (1) to secure from the responsible federal agencies the written justification for routing these shipments of nuclear wastes through highly populated metropolitan areas; and (2) to require that all future shipments be routed through less populated areas unless the responsible federal agencies can demonstrate an unassailable need to transport such nuclear waste through metropolitan St. Louis.

BE IT FURTHER RESOLVED, that the City of Webster Groves can not and will not accept liability for a risk of this magnitude to its residents and their property;

BE IT FURTHER RESOLVED, that the City Manager is directed to provide copies of this resolution to the appropriate state and federal agencies and to the Missouri members of the United States Senate and House of Representatives.

Adopted this 22nd day of July, 1986.

Glenn Sheffield
MAYOR

ATTEST:

Mary Louise Miller
CITY CLERK

EG&G Idaho

INTEROFFICE CORRESPONDENCE

Date: September 18, 1986

To: J. M. Wilson

From: T. A. Smith

Subject: REPORT ON KIRKWOOD MEETING REGARDING TMI-2 FUEL SHIPMENTS - TAS-19-86

The public meeting in Kirkwood, Missouri on Wednesday, September 10, 1986 was held at the request of Kirkwood Mayor Herbert Jones in conjunction with a request from Congressman Robert Young of Missouri. A DOE/EG&G Idaho team answered questions regarding the Three Mile Island Unit 2 fuel shipping program from local officials of the St. Louis metropolitan area and a representative of the Citizens Against Radioactive Transport (CART) group. To keep the meeting orderly, Mayor Jones arranged the meeting format to preclude debate and comments from the public. With the exception of a few instances of heckling from the CART group, the meeting was very orderly and the reception given the DOE/EG&G Idaho team very positive. The DOE/EG&G Idaho team answered the questions in a professional and thorough manner. The meeting seemed very productive in that it appears to have alleviated the concerns of many local officials and satisfied their constituents' requests for information regarding the program. News media coverage was moderate.

The meeting was held from 8 p.m. to about 10:30 p.m. at the Kirkwood Community Center Theater. The theater has a seating capacity of 400 and approximately 200 people attended. The audience included some 30-40 local and state officials, including Lieutenant Governor Harriet Woods, a candidate for the Senate seat now held by Thomas Eagleton. The audience also included about 25 members of the CART group. News media in attendance included most of the major agencies in the St. Louis area.

The meeting format provided for a panel of local representatives to ask questions to a second panel consisting of DOE/EG&G Idaho personnel, a Union Pacific railroad delegate and a representative of the Missouri State Emergency Management Agency. Persons in the audience were not allowed to ask questions but were provided the opportunity to submit written questions for the local officials or CART representative to ask.

Members of the panel of local representatives were St. Louis County Executive Gene McNary, Kirkwood Mayor Herb Jones, Webster Groves Mayor Glenn Sheffield, St. Louis Municipal League Executive Director Natyalie Rullkoetter, City of St. Louis Director of Public Safety Tom Villa, and CART representative Kay Drey.

The moderator was Don Corrigan, Editor-in-Chief of the Webster-Kirkwood Times. Edith Page, Project Director of Hazardous Waste Programs, U.S. Office of Technical Assessment, served as a neutral technical advisor to the moderator.

"Providing research and development services to the government"

The DOE/EG&G Idaho team consisted of Dave McGoff, DOE-NE, Director of the LWR Safety & Technology, Reactor Deployment, and Nuclear Energy offices; Paul Grimm, DOE-DP Transportation; Phil Grant, EG&G Idaho TMI Programs Manager; and Terry Smith, EG&G Idaho Public and Employee Communications. McGoff, Grimm and Grant served on the panel, while Smith provided logistical support and information coordination. Union Pacific was represented by Leo Tierney, Manager Environmental Controls, and the Missouri State Emergency Management Agency was represented by William Johnson, Chief of the Technological Hazards Branch.

Questions asked by the local representatives panel were focused mainly on the following subjects: emergency response in the event of a shipping accident, the justification for moving the material from TMI to the INEL, route selection, special trains as opposed to normal train service, thermal evaluation of the shipping cask and performance in the event of a fire, liability, and the shipping of two casks at one time as opposed to shipping only one. The local officials and the audience, with the exception of the CART group, seemed satisfied with the responses given to the questions. The two issues most often asked about involved justification for moving the material from TMI to the INEL and the use of expedited train service as opposed to normal train service. Some of the local officials indicated they would be deeply concerned if expedited train service is not continued for the remainder of the shipping campaign.

In summary, the local officials seemed very satisfied with the information presented at the meeting. This was probably a result of the thorough manner in which the questions were answered and because Edith Page confirmed many of the statements in her role as a neutral technical advisor. At one point, Edith Page was heckled by a CART member of the audience when she said that risk analyses show that cigarette smoking presents a greater risk to the public than the shipping of spent nuclear fuel.

The consensus of the DOE/EG&G Idaho team is that the meeting was very productive to the TMI-2 fuel shipping program because it seemed for the most part to satisfy the concerns of the local officials and many other people in the audience. This opinion was confirmed by several independent sources, including Al Wyman, KMOV-TV; Don Corrigan; Mayor Jones; Mayor Sheffield; R. D. Ross, the governor's designee; members of Congressman Young's staff, and Dr. John Gantz, of the St. Louis Metropolitan Medical Society. At the conclusion of the meeting, the DOE/EG&G Idaho team received a warm round of applause from the audience.

le

cc: A. A. Anselmo
L. J. Ball
W. A. Franz
E. N. Fray
P. J. Grant
R. C. Schmitt
W. J. Sorensen
D. L. Uhl
J. O. Zane
Central Files

OFFICE OF THE CITY CLERK
City of Pittsburgh
510 City County Building, Pittsburgh, Pennsylvania 15219

Michael Perry
City Clerk

(412) 255-2138

April 30, 1987

Mr. Terry Smith
Information Coordinator & Spokesman
E. G. & G.
Idaho, Inc.
Public Information Office
P.O. Box 1625
Idaho Falls, Idaho 83415

RE: Bill No. 2133 - Petition from the residents of the City of Pittsburgh requesting a public hearing concerning the shipment of highly radioactive material from Three Mile Island; and also the transportation of toxic materials through the City of Pittsburgh.

Dear Mr. Smith:

This is to inform you that the Members of Pittsburgh City Council have scheduled a public hearing concerning the above mentioned subject matter, to be held Tuesday, May 5, 1987 at 10:00 o'clock, a.m. Council Chambers, Fifth Floor, City-County Building, 414 Grant Street, Pittsburgh, PA 15219.

Your presence or a representative from your office is requested to attend this public hearing.

Very truly yours,

Michael Perry
City Clerk

/kp

Resolution No.

WHEREAS, the recent railroad accident beneath the Bloomfield Bridge occurred on the same rail lines on which the Three Mile Island radioactive fuel fragments and debris are shipped; and

WHEREAS, recently the train carrying the Three Mile Island nuclear waste was involved in an accident with a motor vehicle in St. Louis when that vehicle went around a guard barrier and attempted to race across the tracks before the train passed; and

WHEREAS, the dangers and grave risks inherent with the shipment of radioactive material through major metropolitan areas are so significant that they should be avoided without qualification; and

WHEREAS, the Federal Government is required by the National Environmental Policy Act (42 U.S.C.S. 4321, et. seq.) to perform an Environmental Impact Study and to issue an Environmental Impact Statement whenever there is any federal action "significantly affecting the quality of the human environment"; and

WHEREAS, this statement is required to include any possible alternatives to the proposed action[42 U.S.C.S. 4332(C) (iii)]; and

WHEREAS, the Federal Government never completed such a study, examined any possible alternatives or issued such a statement relative to the transportation of the radioactive material by railcar from Three Mile Island.

NOW, THEREFORE, BE IT RESOLVED, that the Council of the City of Pittsburgh does hereby respectfully request that the Solicitor for the City of Pittsburgh file suit against the United States Government under the National Environmental Policy Act and to seek an injunction to prevent the shipment of radioactive fuel fragments and debris from Three Mile Island until such time as the Federal Government has completed an Environmental Impact Study and issued an Environmental Impact Statement.

PRESENTED BY COUNCILMAN MARK H. POLLOCK

In Council ....19........., *Read and adopted.*

____
PRESIDENT OF COUNCIL

Attest:______________________________
CLERK OF COUNCIL

Recorded in Resolution Book, Vol.____***Page***______, __________

day of________________ ***19***____

CITIZENS • AGAINST • RADIOACTIVE • TRANSPORT

CART CONCERNS

1. WHY MUST THE FUEL BE MOVED ?

The DOE says the fuel is going to a goverment facility in Idaho for laboratory testing. However, Three Mile Island (TMI) fuel samples have been analyzed at that facility since 1983; tons of additional fuel were shipped there in 1986. We question the need to ship the entire fuel core. We also question the value of tests performed on fuel physically altered (chopped up) during its removal.

The DOE also claims the fuel is in too unpredictable a condition to leave at Three Mile Island. If that is true, we question how predictable the fuel is as it's being transported by rail across ten states.

The facility in Idaho will provide only temporary storage in a concrete pool; the fuel will have to be moved again, eventually. No one knows its final destination.

2. WHY MUST THIS EXTREMELY HAZARDOUS MATERIAL PASS THROUGH LARGE CITIES ?

The DOE has not shown that this route, which passes through Pittsburgh, Canton, Indianapolis, St. Louis, Kansas City, Topeka, and other cities, is the safest route possible. When the Army recently considered shipping old nerve gas weapons across the country, it planned to use the best track through least populated areas. As a result, Army trains would have traveled hundreds of miles to avoid major metropolitan areas like St. Louis.

Union Pacific has been chosen to carry the cargo west of the Mississippi; however its "track record" is disturbing. In a rececnt 10 month period, there were four train derailments on a stretch of Union Pacific tracks near Washington, MO. In September 1986, near Marysville, Kansas, a train derailed and caught fire JUST ONE DAY before the TMI train traveled on those same tracks. In November 1986, 42 cars of a freight train on Union Pacific tracks derailed in Otterville, MO.

3. HOW RELIABLE ARE THE CONTAINERS THAT CARRY THE RADIOACTIVE MATERIAL ?

There has been NO testing of the ACTUAL casks that are transporting the cargo. The only testing that has been performed was by computer or with quarter-scale models.

Just 2 months after the Nuclear Regulatory Commission approved the canisters (which are inside the casks), the DOE requested permission to change the O-ring seals from metal to plastic; the metal seals were found to be defective. We have been unable to obtain proof that any tests were performed on the plastic O-ring replacements.

Also, the DOE's own documents show the potential for an explosion should special safeguards inside the canister fail. Dr. Marvin Resnikoff, a respected nuclear physicist who has studied the matter, warns that a long-duration, intensely- hot fire could lead to the release of radioactive fission products. The likelihood of that kind of fire would increase if the TMI casks were shipped on trains carrying other flammable, hazardous cargo;such "mixed use" trains are allowed after the third shipment under DOE's contract with Union Pacific.

4. IN THE EVENT OF A COLLISION, DERAILMENT, FIRE OR OTHER ACCIDENT, WHO WOULD TRY TO HANDLE THE EMERGENCY ?

Federal documents show it could take federal emergency response teams 6 to 8 hours to arrive on the scene. In the meantime, local authorities would attempt to monitor and cordon off the contaminated areas and would try to evacuate people from homes, businesses, and schools.

5. JUST HOW HAZARDOUS IS THE TMI CARGO ?

A medical research laboratory is classified "contaminated" when only a tiny fraction of one curie of radioactivity is spilled. Each shipment will contain roughly 80,000 to 200,000 curies.

6. IN THE EVENT OF AN ACCIDENT, WHO WOULD BE HELD LIABLE FOR DAMAGES ?

... damages that might include illness, death, genetic defects, and the loss of property. Your homeowner's insurance policy does NOT cover radioactive contamination. And the Congress has set the liability limit for DOE contractors at only 500 million dollars.

7. AND FINALLY...A DANGEROUS PRECEDENT?

Federal documents show these shipments may be only the first of many, as mounting radioactive waste from nuclear power plants in the East is shipped for storage out West. Our neighborhoods could become the radioactive waste corridor of the nation.

Consider the space shuttle Challenger and what NASA officials knew about those O-rings. Consider Three Mile Island...Chernobyl. Accidents happen... and they happen despite assurances from corporate or government officials.

EG&G Idaho

INTEROFFICE CORRESPONDENCE

Date: June 5, 1987

To: P. J. Grant

From: T. A. Smith -Terry Smith

Subject: REPORT ON PITTSBURGH REGARDING TMI-2 FUEL SHIPMENTS - TAS-17-87

SUMMARY

This report provides an update on the situation in Pittsburgh, PA relevant to the Three Mile Island Unit 2 (TMI-2) fuel shipments and a summary of the May 5, 1987 public hearing. In Pittsburgh sensitivity to the TMI-2 fuel shipments increased dramatically following the April 11, 1987 Conrail derailment in the city that led to the evacuation of some 15,000 residents of the Bloomfield area. My contacts tell me that the hysteria caused by that incident is subsiding. The May 9 editorial in the Pittsburgh Post-Gazette, which stated that the shipments were being conducted in a safe manner and that the city should allow passage to the trains, has apparently helped to calm down the situation. Nevertheless, Conrail police are concerned about threats of demonstrations that could involve human blockades of the next shipment. These threats were initially made during the May 5 public hearing, specifically by Joseph Hughes, an anti-shipment organizer, and by City Councilmen Jack Wagner and Richard Givens. Conrail police are working with Pittsburgh city police to ascertain the likelihood of problems during the next shipment, and will keep us informed of the situation.

In the primary city election held May 19, three incumbent city councilmen were defeated. It appears the TMI-2 fuel shipments were not a factor in the election. However, one of those defeated, Richard Givens, was among the most critical of the shipping program during the May 5 public hearing. On the other hand, Jim Ferlo, who testified during the hearing and was also critical of the shipping program, won a position on the Democratic ticket for general council elections in November.

Regarding actions taken by the council subsequent to the April 11 Bloomfield derailment, the city solicitor's office is currently investigating the possibility of filing suit against DOE regarding compliance with the National Environmental Policy Act (NEPA), as directed by the city council in its nonbinding resolution unanimously passed May 4. I have been directed by Willis Young, DOE-ID, to refer inquiries from the city solicitor's office to the ID Office of Chief Counsel. The council also passed a preliminary measure on May 6 to limit train speeds through the city to 15 m.p.h. Final action on that measure has been tabled.

I am currently trying to obtain a transcript of the public hearing. City Clerk Michael Perry says copies will not be available until sometime in June.

CITY ELECTIONS

Incumbent councilmen defeated in the city primary election May 19 were Richard Givens, Jim O'Malley and Steve Grabowski, all on the Democratic ticket. Incumbent council members winning nomination on the Democratic ticket were Jack Wagner and Michelle Madoff. Also winning nominations on the ticket were Jim Ferlo, described in newspaper accounts as a community organizer and former city auditor; Michael Coyne, a teacher at Community College; and Otis Lyons, Jr., the county deputy register of wills and described in newspaper accounts as the only black among leading candidates.

Republicans winning nomination for council seats are Elmer McClung, Samuel Hurt, Mildred Dezi, Douglas Hugney, and Gerard Dauginikas. All five ran unopposed but are not considered as strong contenders in the general election.

The TMI-2 fuel shipments were apparently not an issue in the election, since all present members of the council have endorsed measures to stop the shipments or to reroute around the City of Pittsburgh. Rather, the election results seem to demonstrate decreased support for Mayor Caliguiri, who endorsed nomination of Givens, Grabowski and O'Malley, but declined to support Wagner and Madoff, who are frequently critical of his administration.

ACTIONS TAKEN BY CITY COUNCIL

On May 4, 1987 the council unanimously approved a nonbinding resolution directing the city solicitor to file suit against the federal government regarding NEPA compliance on the TMI-2 fuel shipments. The resolution was introduced by Councilman Mark Pollack, who also introduced the resolution approved by the council last July that requested DOE to reroute around the City of Pittsburgh. The latest resolution directs to solicitor to investigate the possibility of obtaining an injunction to stop the shipments. I have been in contact with Ashely Schannauer, an assistant to the solicitor, both prior to and after passage of the resolution. In a conversation with Schannauer on May 19, 1987 said he was trying to obtain copies of NUREG 0170, the generic NRC transportation Environmental Impact Statement, and NUREG 0683, the TMI Programmatic Environmental Impact Statement, and said he may want further documents from us. I discussed this conversation with Willis Young and he instructed me to direct Schannauer to make any requests for documents in writing to Betty Hollowell, DOE-ID Office of Chief Counsel. I passed this information on to Schannauer on May 22, 1987. My discussions with Schannauer show that the solicitor's office is just getting started with its investigation.

On May 6, the council passed a preliminary measure to restrict train speeds in Pittsburgh to 15 m.p.h. On May 22, Bob Libkind, Conrail Public Relations, told me that Conrail attorneys had discussed this matter with the Pittsburgh solicitor's office and informed them that local speed restrictions have not stood up in court. Libkind said the city has tabled final action on the measure.

PUBLIC HEARING

The public hearing regarding the shipments of TMI-2 core debris and hazardous materials in general through the Pittsburgh area was convened before the Pittsburgh City Council at 10 a.m. on May 5, 1987 and concluded at about 3:30 p.m. the same day. The hearing was called as the result of a citizens' petition submitted to the council in late March. DOE was invited to send representatives on April 30, 1987. Phil Grant, EG&G Idaho TMI-2 Programs manager, and Terry Smith, EG&G Idaho Public Information Office, attended the meeting to represent the shipping program. Conrail was represented by George Turner, a marketing director, and William Murphey and Rick Pyson, both Pittsburgh area operations supervisors. At our request, the Pennsylvania Emergency Management Agency (PEMA) sent Monk Hillyard, our main contact on the shipments, to represent the agency. DOT and NRC were invited to send representatives to the hearing but declined. Mayor Caliguiri did not attend the hearing. Eight city council members were present at the beginning of the hearing, but members frequently left, some to return later, others to not. The number of council members present at any given time varied from eight to two and averaged about four. The hearing was initially chaired by Council President Ben Woods, who left about half way through the proceedings and turned the chair over to Councilmen Richard Givens. Some 25 persons testified at the hearing. Only one, Harvey Meieran, a nuclear industry private consultant from the Pittsburgh area, testified in favor of the shipments. News media coverage was moderate; about a half-dozen local news agencies were represented. The hearing was broadcast live on Pittsburgh's city public television channel. Some 125 persons attended, most of them affiliated with various environmental and antinuclear groups. The hearing had somewhat of a circus atmosphere. Some attendees brought their young children, others carried anti-shipment signs, and one man attended wearing a yellow raincoat and some sort of a gas mask. In spite of the crowd, Woods kept the hearing in good order, not allowing people to interrupt speakers and having the Sergeant-at-Arms physically evict one man for repeated outbursts.

Those who testified included Jim Ferlo, a candidate for city council, several members of the clergy, several local officials from surrounding communities, representatives of several local environmental groups, a local attorney, several private citizens listing no affiliations, Liz Hughes of the Consumer Party, Michael Freeman, president of the Committee of Sane Nuclear Policy and Kay Drey, organizer and chief spokesperson of the St. Louis-based Citizens Against Radioactive Transport (CART) group. Listed as speakers, but not in attendance were Mina Hamilton, director of the Sierra Club Rad. Waste Campaign; Marvin Resnikoff, Sierra Club; Lindsay Audin, Citizen Institute for Positive Energy Policy; and Fred Millar, Environmental Policy Institute.

Most of the testimony was directed toward the TMI-2 fuel shipments, although some speakers focused more on other hazardous waste shipments. Several speakers, including Pittsburgh Director of Public Safety Glenn Cannon, said the city is not prepared to handle an accident involving nuclear materials. Other speakers, including Freeman and Drey, alleged that the TMI-2 fuel is being transported to the INEL for military purposes, supposedly so that the plutonium can be extracted using the new SIS facility. Other speakers, including Freeman and Drey again, charged that DOE is bailing out GPU and cleaning up the facility for a TMI-2 restart. The TMI-2 fuel shipments were called "a Chernobyl waiting to happen," "technological terrorism," "a spill and kill" program. One member of the clergy cautioned us against committing "social sin by engaging in activities dangerous to the public for a profit motive." A few speakers, called for stopping the shipments by committing acts of civil disobedience.

Following public testimony, members of the city council questioned invited guests including Phil Grant, Monk Hillyard and the Conrail representatives. Several of the council members used the occasion to make statements, it would appear with political motivation. Councilman Mark Wagner suggested that the trains be routed to the north of Pittsburgh on track that would take us through the cities of Buffalo and Cleveland. Wagner said he didn't care about shipping through those cities but was only concerned about Pittsburgh. Councilman Richard Givens suggested that we use waterways for the shipments that would involve the Panama Canal or transportation across Mexico. Both Wagner and Givens suggested that the city might take "illegal actions" by blocking the shipments if we do not reroute around the city. In general, the council did not seem interested in the logic for using the Conrail mainline route that passes through Pittsburgh or in the numerous safety precautions incorporated in cask design. They seemed only to want the shipments rerouted to avoid the City of Pittsburgh.

Conrail representatives answered questions mainly about alternative routes, the April 11 Bloomfield accident, and hazardous materials shipments in general. It is my impression that the Conrail representatives were not supportive of the

TMI-2 fuel shipping program during the hearing. At one point George Turner stated that Conrail would be very happy it never had to touch another load of TMI material.

Monk Hillyard, of PEMA, was very support of the shipping program and explained how we working closely with his agency, and how his agency passes along information to local emergency response personnel.

At the request of City Councilman Mark Pollack, Kay Drey was allowed to sit at the council table during the final stages of the hearing to serve as a "technical expert." Drey brought up many of the old questions that have been answered time and time again--questions on NEPA compliance, cask design, hydrogen generation and zirconium. Phil Grant refuted all the allegations raised by Drey.

ka

cc: A. A. Anselmo
L. J. Ball
J. M. Broughton
W. B. Engel
W. A. Franz
P. J. Grant
K. M. Haddock
H. W. Reno
R. C. Schmitt
M. J. Tyacke
D. L. Uhl
J. M. Wilson
Central Files

Tuesday, May 5, 1987
10:00 A.M. Bill No. 2133

Invited

No Show → Mayor Richard S. Caliguiri
or Representative

Glenn Cannon, Director
Department of Public Safety

Chief John Leahy
Bureau of Fire

Chief William Moore
Bureau of Police

Chief Robert Kennedy
Emergency Medical Services

Paul Imhoff, Superintendent
Bureau of Building Inspection1

William Murphy
~~Community Relations~~ (CONRAIL)
Operations Supervisor

Terry Smith, Information Coordinator
E G & G, Idaho, Inc.

George Turner
~~Community Relations~~ (CONRAIL)
Marketing Director

Phil Grant, TMI Program Manager

No Show → Charles MacDonald, Chief
Transportation Certification Branch
Nuclear Regulatory Commission

Monk Hilyard, Hazardous Materials/
Radiological Officer (PA Emergency
Management Agency)

No Show → Bernard Schillings
Motor Carrier Safety Office
Dept. of Transportation

Speaker's List

Jim Ferlo

Councilman Mark Weitzman
Wilkinsburg Borough

Michael Freeman, President
Committee for a Sane Nuclear Policy

Jim McCue

Gary Doebler

Patti Heckart
Womens Peace Network

Kay Drey
C.A.R.T.
University City, MO

Gordon MacLeod, M.D.
University of Pgh

Not present → Mina Hamilton, Director
Sierra Club Rad. Waste Campaign
New York, NY

Liz Hughes
Consumer Party

R. Mabel Karsch
Emanuel U.M. Church, Elliott, PA

Anne Feeney, Attorney
Edgewood, PA

No Show → Marvin Resnikoff
Sierra Club, New York, NY

No Show → Lindsay Audin
Citizen Inst. for Positive Energy Policy
New York, NY

No Show → Fred Millar
Environ. Pol. Inst., Washington, D.C.

Mayor Charles Martoni
Swissvale, PA

Father Jack O'Malley
St. Mary's Chruch, Lawrenceville

Joseph Hughes

Daniel Pagath

Reverend Keith Grill, Pastor
St. John's Lutheran Church

John Tokarski
Hazelwood Community

Newlon Tauxe, M.D.
Professor of Nuclear Medicine ← No Show
University of Pgh

Y.S. Tang, Dr.
University of Pgh ← no Show

Helen Shields

Bridgette Shields
Three Rivers Sane

Frances Shane

Harvey Meieran

Gilda DeFerrari
Beaver County Nuclear Weapons Freeze

Henry Posner III

INEL

Idaho National Engineering Laboratory

April 11, 1988

Mr. Peter Mygatt, Director
Office of External Affairs
Idaho Operations Office - DOE
785 DOE Place
Idaho Falls, ID 83401

MEETINGS ON TMI-2 SHIPMENTS IN ST. LOUIS AND COLUMBIA, MO - TAS-5-88

Dear Pete:

On April 4-7, 1988 I met informally with several local officials in the St. Louis area, with several news media representatives, and with individuals of companies or organizations sympathetic to the need and procedures for shipping the Three Mile Island Unit 2 (TMI-2) core debris to the Idaho National Engineering Laboratory (INEL). My objectives for the meetings were to (1) establish improved communications with concerned local officials, (2) provide the news media with accurate information, (3) gain new insights into what we might do to alleviate further public relations problems in the area, and (4) provide groups sympathetic to the shipments with factual information which they can disseminate.

In meeting those objectives, it is my impression that (1) improved communications have been established with local officials and that we now have the opportunity to work informally with them to resolve concerns they have on the shipments, (2) the news media will make more of an attempt at accuracy in their news reports, (3) there is only a very small group in the St. Louis area that is actually concerned about the shipments but that they have exerted enormous pressures on local officials and members of Congress to oppose the shipments, and (4) that groups sympathetic to the needs and procedures for the TMI-2 shipments will assist us by disseminating factual information.

During my stay in the St. Louis area, I met with the following 10 individuals or groups: (1) Dr. Jay Kunze, William Miller, and Don Alger, Nuclear Engineering Department professors at the University of Missouri-Columbia, and all members of the American Nuclear Society (ANS); (2) Michael Cleary, public information supervisor for Union Electric at the Callaway Nuclear Plant; (3) assistant managing editor, Christine Bertelson, reporter, and Dale Singer, assistant editorial page editor; (4) Bill Kuehling, of the St. Louis mayor's office; (5) Kent Martin, reporter for KMOX-Radio; (6) R.D. Ross, director of the Missouri State Emergency Management Agency; (7) Dick McAleenan and Krista Kotur, public relations officials for Union Electric headquarters in St. Louis; (8) Dr. William Hope, of Riedel Environmental Services and formerly the St. Louis Health Department director; (9) Mayor Herb Jones, Kirkwood, Mayor Glenn representatives of the St. Louis Post-Dispatch, including Ron Willnow, senior

EG&G Idaho, Inc. P.O. Box 1625 Idaho Falls, ID 83415

bcc: A. A. Anselm
L. J. Ball
W. B. Engel
W. A. Franz
J. H. Nelson
H. W. Reno
R. C. Schmitt
Central Files

Sheffield, Webster Groves, and Mayor Pat Killoren, Crestwood; and (10) Paul Watkins, regional director of public relations for Union Pacific.

Two requests for meetings or presentations were made: (1) the local chapter of the American Nuclear Society (ANS) requested that I do a presentation at a dinner meeting tentative scheduled for April 20, 1988. With your permission, I will provide a status report on the shipments to the ANS and discuss community relations problems and resolutions. (2) the mayors of Kirkwood, Webster Groves and Crestwood, communities in the St. Louis metropolitan area, requested that a Department of Energy/EG&G Idaho delegation meet with them and members of the Citizens Against Radioactive Transport (CART) to answer lingering questions they have about the TMI-2 shipments. The mayors will make a formal request to Dave McGoff, DOE-NE, but are tentatively looking at holding the proposed meeting on April 22, 1988. The mayors intend that the meeting will not be public nor will news media be present.

Please contact me if you have any questions.

Very truly yours,

Terry A. Smith
Public Information Office

cas

cc: D. Bedell, GPU Nuclear
L. H. Harmon, DOE-DP
P. E. Litteneker, DOE-ID
D. J. McGoff, DOE-NE
J. D. Threlkeld, DOE-CP
J. M. Wilson, EG&G Idaho

Idaho National Engineering Laboratory

May 5, 1988

Mr. Peter Mygatt, Director
Office of External Affairs
Idaho Operations Office - DOE
785 DOE Place
Idaho Falls, ID 83401

REPORT ON MAYORS' MEETING IN KIRKWOOD, MO - TAS-6-88

Dear Pete:

On April 25, 1988 a DOE team met at Kirkwood, Missouri with three St. Louis area mayors and several members of Citizens Against Radioactive Transport (CART). The purpose of the meeting, scheduled at the request of Mayor Glenn Sheffield, Webster Groves, Mayor Herb Jones, Kirkwood, and Mayor Pat Killoren, Crestwood, was to answer questions from CART and the mayors on the Three Mile Island Unit 2 (TMI-2) shipments. The three mayors requested the meeting as a follow-up to a March 22, 1988 meeting in Washington, D.C. and an informal meeting I held with them on April 7, 1988 in Kirkwood. Also present at the invitation of Mayor Sheffield was Paul Schleer, deputy director of the Missouri State Emergency Management Agency (SEMA), the state agency we work with for the shipments. News media representatives were not invited, nor did any attempt to attend. The meeting lasted about two and one-half hours.

Members of the DOE team were Dave McGoff, DOE-NE, Larry Harmon, DOE-DP, Debra Kurilchyk, DOE-CP, Phil Grant, a consultant to GPU Nuclear at TMI, and myself. Representing CART were Kay Drey, Dotty DeLassus, Debra Wilson, Chris Wissler, Diane Sheehan and another woman whose name I don't have. Dave McGoff served as team leader for DOE, while Kay Drey did most of the talking for the CART group.

Most of the questions were in the following subject areas: (1) legality of the shipments and reasons for taking the entire core to the INEL, (2) licensing criteria, testing and the safety of the transport casks, (3) and emergency response capabilities.

Dave McGoff answered questions on the legality of the shipments and the reasons for taking the entire core, explaining that DOE has statutory authority under the Atomic Energy Act of 1954, that Congress has been kept informed of plans for core acquisition and has funded DOE activities and that the entire core is necessary for the DOE research program. The mayors seemed satisfied with his answers, as did some of the CART members.

Questions on cask licensing criteria, testing and safety were answered mainly by Phil Grant. These questions were basically the same questions that have been asked and answered repeatedly during the past two years. Again, the mayors seemed satisfied with those answers, as did some of the CART members.

Questions on emergency response capabilities were answered by Larry Harmon and Paul Schleer. Mayor Jones said he is now satisfied that Kirkwood emergency response personnel could provide an adequate first line response in the event of a TMI-2 train accident, and that state and federal experts would be on hand to assist. Mayor Killoren said she was still uncomfortable about emergency response capabilities but hoped that a DOE Emergency Response Training Seminar scheduled in the St. Louis area for the following day would satisfy her concerns.

Following the meeting, members of the DOE team agreed that the meeting was extremely successful, in that it met our objectives of satisfying the mayors concerns. The mayors said they will make future public statements that their concerns about the shipments have been satisfied. However, Mayor Jones told us that he is still not completely comfortable with Union Pacific Railroad operations and asked us to do whatever we can to ensure safe rail handling of the TMI-2 shipments. We have passed the mayor's comments on to Union Pacific officials.

To my knowledge, there have been no subsequent news media accounts regarding the meeting, nor have there been any news media reports on the DOE Emergency Response Training Seminar that was held in the St. Louis area the following day.

The seminar, held at the request of Congressman Jack Buechner, was attended by approximately 50 St. Louis area emergency response personnel. Several attendees were from the State of Illinois. The Welcome was given by the Congressman, who complemented DOE for quick response in meeting his request. Phil Grant gave a brief presentation on shipping procedures and the cask design. The seminar itself was presented by Harold Reed and Doug Stanceli, of SAIC, a DOE contractor at Oak Ridge.

Seminar attendees were very attentive and many complemented DOE on the excellence of the presentation. Representatives of SEMA were also impressed and asked Larry Harmon to schedule a similar seminar for the Kansas City area. That seminar will apparently be held sometime in early June.

Other meetings of interest: (1) On April 21, 1988 I gave a presentation on the TMI-2 shipping program to members of the American Nuclear Society at Columbia, Missouri. Attendees expressed support for the shipping program and some of them will help us in disseminating factual information if the future opportunity or need arises. (2) On the morning of April 21, Union Pacific Railroad officials provided me with a rail tour of the route used by the TMI-2 trains through the St. Louis area. Mayor Jones, of Kirkwood, was also present for the tour. At our request, Union Pacific officials have been working closely with Mayor Jones to satisfy his concerns regarding track safety and railroad operations.

Please contact me if you have any questions.

Very truly yours

Terry A. Smith
Public Information Office

alg

cc: D. Bedell, GPU Nuclear
P. J. Grant, TMI
L. H. Harmon, DOE-DP
D. Kurilchyk, DOE-CP
P. E. Litteneker, DOE-ID
D. J. McGoff, DOE-NE
J. D. Threlkeld, DOE-CP
J. M. Wilson, EG&G Idaho

bcc: A. A. Anselmo
L. J. Ball
W. B. Engel
W. A. Franz
J. H. Nelson
H. W. Reno
R. C. Schmitt
T. A. Smith file
Central Files

Appendix H

Information Package

canisters was demonstrated in a series of full-scale 30-foot drop tests conducted at Oak Ridge National Laboratory. Analysis showed that the canisters experienced no serious damage to the exterior shell or internal structure.

The fuel canisters and the NuPac 125B shipping cask make up a shipping package that provides three separate levels of protection for the radioactive cargo. The extensive cask and canister testing program has demonstrated that the shipping packages will remain leaktight even in the event of a sequence of severe accident conditions.

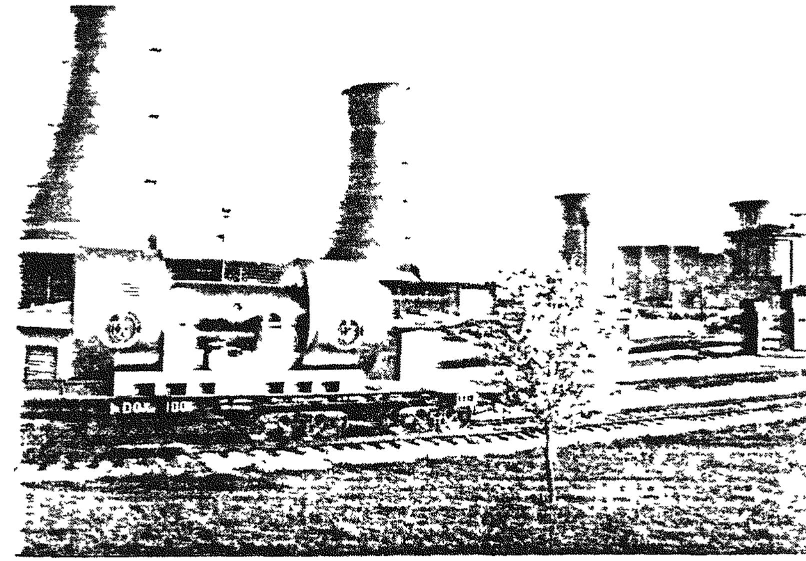
Thorough inspection

Each shipment will be thoroughly inspected before leaving Three Mile Island. The Department of Energy, the Nuclear Regulatory Commission, and the Department of Transportation ensure that cask, cargo and railcar meet all necessary federal requirements for safe shipment. A thorough inspection of the railcar, including cask tiedown, is conducted to show hat the railcar meets safety requirements of the American Association of Railroads. In addition, radiation surveys are performed prior to transport. Prior to the start of shipments, track that the shipment will cross was thoroughly inspected by the Federal Railroad Administration.

Idaho National Engineering Laboratory

INEL

Three Mile Island-2 fuel shipping program



TMI-2 fuel shipping cask

Shipments by rail

Fuel and structural core materials from the damaged Three Mile Island Unit 2 commercial reactor at Middletown, Pennsylvania, will be shipped by rail to the Department of Energy's Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. Shipments will be accomplished using shipping casks specially designed to withstand severe accident conditions and certified by the Nuclear Regulatory Commission. Loaded casks will be carried by Conrail from Middletown to East St. Louis, Illinois, where the the shipments will be transferred to Union Pacific for shipment to the INEL. Approximately 35-40 shipments will take place during the next 2&1/2 years. At the INEL, the fuel and core materials will be studied and analyzed as part of the DOE's TMI-2 Accident Evaluation Program to provide a complete understanding of the TMI-2 accident sequence and a better understanding of nuclear fuel behavior during severe reactor accidents. The fuel and core materials will be placed in interim storage at the INEL until a national repository or other alternatives become available for ultimate disposal.

Rail shipment was selected as the means for transporting the TMI-2 fuel and core materials because it is safe, economical and will greatly reduce the number of shipments as compared to truck transport. Shipping by rail can accomplish the task with 35-40 shipments, whereas shipping by truck would require approximately 250 shipments. The routes proposed by the railroads utilize the highest quality tracks available. Conrail and Union Pacific were selected as the carriers because of their extensive experience in transporting radioactive materials. Both of these railroads consistently earn railroad industry recognition for safety of operations and maintenance of track.

In February of 1986, the governor's designee in the states of Pennsylvania, Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, Colorado, Wyoming and Idaho were notified of the shipping plan. Officials of DOE and EG&G Idaho Inc., a prime DOE operating contractor at the INEL, will remain in contact with state officials to answer questions they might have about the shipping campaign.

Special cask design

Two specially designed NuPac 125B rail casks were designed and fabricated by Nuclear Packaging Inc. for the shipments. The casks are 280 inches long by 120 inches in diameter and will weigh about 90 tons when fully loaded. Each cask provides two separate vessels for containment. The stainless steel inner vessel includes a hub and spoke arrangement to support tubes which hold loaded fuel canisters. The outer vessel has a composite wall -- three thick layers of metal. The inner shell of the outer vessel is a cylinder of one-inch thick stainless steel. The outer vessel shell is made of two-inch stainless steel. A four-inch void between the two shells is filled with lead for radiation shielding. Attached to each end of the outer vessel are large energy absorbers called overpacks. The overpacks are made of stainless steel and filled with foam that crushes upon impact, absorbing impact energy and protecting the cask body.

Another safety feature of the NuPac 125B is the thermal shield to protect the cask in the event of a fire. The thermal shield consists of wire wrapped around the outer shell, covered by a thin sheet of stainless steel welded over the wire. The resulting air gap between the thin sheet and the outer shell provides heat shielding, since air is such a poor conductor of heat energy.

The structural integrity of the NuPac 125B cask was demonstrated in tests conducted at Sandia National Laboratory. A series of five drop tests, to simulate severe hypothetical accident conditions, were conducted at the Sandia Transportation Technology Center. A 1/4-scale model of the NuPac 125B was constructed for the tests. Three 30-foot drop tests were conducted to simulate an accident where a cask would impact upon an unyielding surface, and two 40-inch drop tests onto a puncture rod were conducted to simulate a puncture accident. Analysis of the 1/4-scale model following the tests showed that the cask remained leaktight without significant structural damage. The tests demonstrated conclusively the safety of the NuPac 125B even in accidents involving severe impacts.

Canister for material

Each cask will hold seven canisters containing fuel and core materials. The canisters, specially designed for the TMI-2 materials, are made of stainless steel and measure 150 inches long by 14 inches in diameter. The integrity of the fuel

TMI-2 Fuel Shipping Program

Highlights

- Fuel and structural core materials from the Three-Mile Island Unit 2 reactor are being shipped by rail from TMI to the Department of Energy's (DOE) Idaho National Engineering Laboratory (INEL).
- Fuel and core materials will be studied and analyzed at the INEL for the DOE's TMI-2 Accident Evaluation Program to understand the progression of events during the accident.
- Shipments started in July 1986.
- Approximately 25 shipments over 2½ to 3 years.
- Fuel and core materials contained in specially designed canisters.
- Shipments will be accomplished using the NuPac 125B shipping cask, certified as a Type B shipping container by the Nuclear Regulatory Commission (NRC).
- Shipments are only about one-fifth as radioactive as typical spent fuel shipments.
- Shipments accomplished in accordance with DOE, NRC, and Department of Transportation (DOT) requirements.
- Total program costs are approximately $22 million. Breakdown as follows: shipping casks, including design, fabrication, testing, licensing, and railcars, about $4 million; transportation, about $6 million; TMI-site-related costs for shipping preparation, about $2 million; INEL operating costs, including receipt, handling, and storage, about $10 million. Costs will be shared by DOE and General Public Utilities (GPU). GPU will pay the Federal Government about $12 million for transportation and interim storage costs.

Canisters

- Total: approximately 350.
- Seven canisters per cask.
- Dimensions: 14 inches in diameter by 150 inches long.
- Constructed of stainless steel and American Society of Mechanical Engineers coded.
- Boron carbide pellets or borated aluminum provide criticality control.
- Each canister contains catalyst materials to recombine hydrogen and oxygen gases from radiolysis.
- There are three types of canisters: fuel canisters to hold damaged fuel assemblies; knockout canisters to collect pieces of core debris from vacuuming operations; and filter canisters to hold fine debris.
- Structural integrity of canisters demonstrated in a series of full-scale drop tests conducted at Oak Ridge National Laboratory.

Shipping Casks

- Three NuPac 125B shipping casks, specially designed and fabricated by Nuclear Packaging, Inc.
- Dimensions: 280 inches long by 120 inches in diameter.
- Weight: approximately 90 tons when fully loaded.
- Each cask provides two separate vessels for containment.
- Inner vessel includes a hub and spoke arrangement to support tubes, which hold loaded fuel canisters.
- Outer vessel has a composite wall consisting of three thick layers of metal: The inner shell is a cylinder of 1-inch thick stainless steel; the outer shell is made of 2-inch thick stainless steel; a 4-inch void between the two shells is filled with lead for radiation shielding.
- Stainless steel overpacks are attached to each end. These are filled with foam to absorb impact energy and protect the cask body.

- Thermal shield consisting of wire wrapped around the outer shell, covered by a thin sheet of stainless steel, providing an air gap for heat shielding.
- Cask is designed to survive severe impact accidents without release of radioactive material (10 CFR 71).
- Drop tests demonstrated conclusively the safety of the NuPac 125B even in accidents involving severe impacts. A one-quarter scale model was subjected to five drop tests at the Sandia National Laboratory Transportation Technology Center. Three drops were conducted from 30 feet (2 drops with the cask at -20 degrees Fahrenheit) onto an unyielding surface. Two drops were conducted from 40 inches onto a puncture rod.

Pre-shipment Inspections

- Each shipment inspected by NRC, DOE, and DOT before leaving TMI.
- Railcar inspection to Association of American Railroads specifications.
- Cask tiedown inspected.
- Radiation surveys.
- Federal Railroad Administration conducted thorough inspection of tracks that shipments will cross.

Transportation

- Rail shipment selected because it significantly reduces the number of shipments required. It would take about 350 shipments by truck.
- Shipments will be accomplished by Conrail, from Middletown to East St. Louis, Illinois, and by Union Pacific from East St. Louis to the INEL.
- Route selection based on using high-quality tracks with carriers that serve the origin and destination and make the trip with the fewest carrier changes and the fewest switching delays.
- Route passes through the States of Pennsylvania, Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, Colorado, Wyoming, and Idaho.

Cooperation with States

- Written notification to Governor's designee for each State enroute.
- Shipment information provided to State emergency response personnel by Governor's designee (State responsibility).

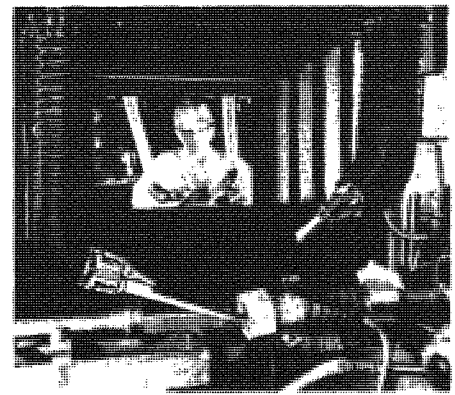
Emergency Planning

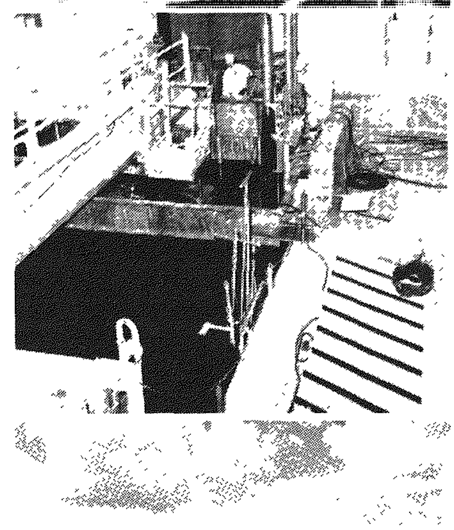
- Railroad carrier communications centers will be in telephone contact with the DOE Idaho Operations Office Warning Communications Center a minimum of once every 4 hours to inform DOE of the status and location of shipment.
- Constant surveillance of the shipment at all times.
- Railroads have emergency plan that provides for immediate notification of local, State, and Federal authorities.
- Railroads have trained personnel for responding to hazardous materials incidents.
- DOE Radiological Assistance Program (RAP) teams available.

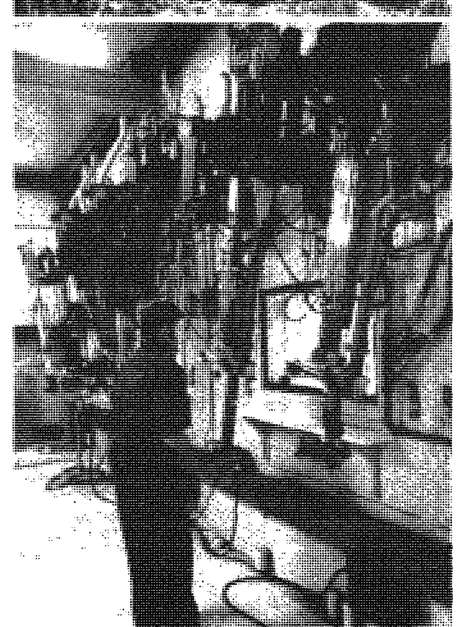
Safety Record

- In the United States, there are approximately 3 million shipments annually of radioactive materials. Of these, about 64,000 are in Type B packages. According to DOT statistics, between 1971 and March of 1985 there were 51 reported transportation accidents involving Type B packages. None of the accidents resulted in package failures or release of contents. Type B packages are defined as packaging designed to transport higher-level radioactive materials, including spent fuel, and to survive severe accident conditions without release of contents.

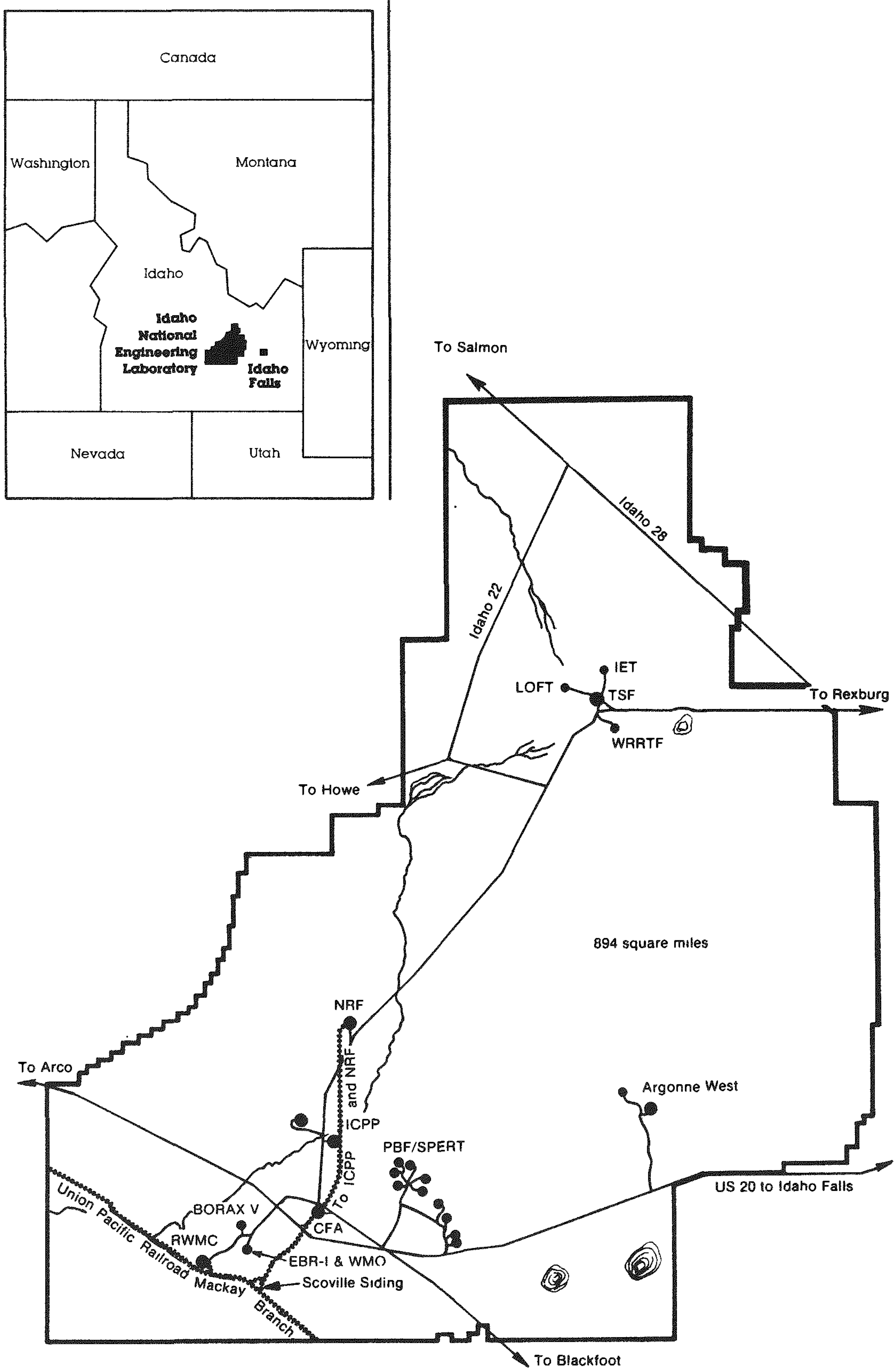
Warm and Hot Cell Facilities at the Idaho National Engineering Laboratory





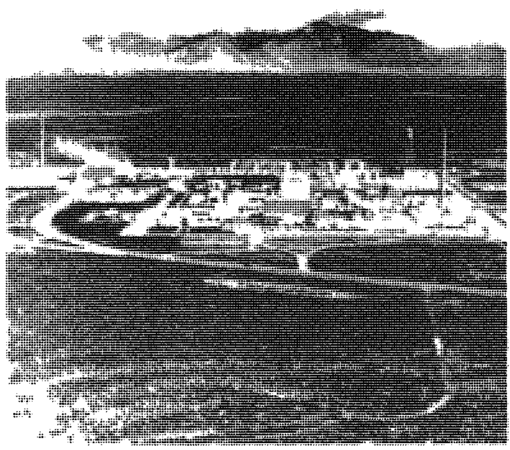


EG&G Idaho

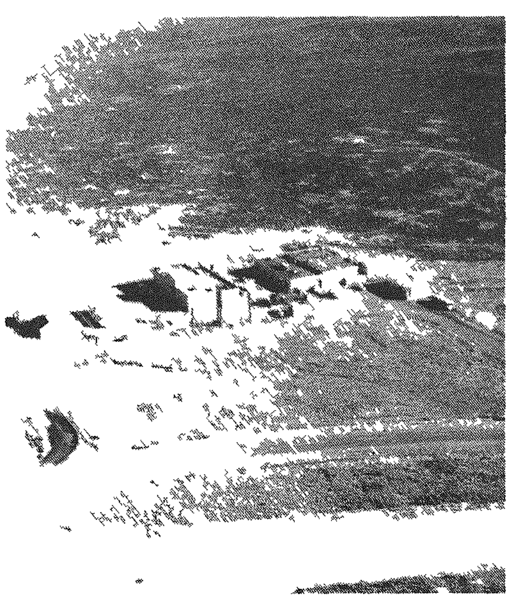


Idaho National Engineering Laboratory (INEL)

Test Area North (TAN)



Test Reactor Area (TRA)



Auxiliary Reactor Area (ARA)

Warm and Hot Cell Facilities at the Idaho National Engineering Laboratory

Radioactive material handling, examination, and interim storage operations are performed routinely by EG&G Idaho in its "Warm" and "Hot" Cell facilities at the Idaho National Engineering Laboratory (INEL)[a] These facilities have the capabilities for the methodical disassembly, detailed analysis, and preparation for storage or disposal of nuclear reactor subassemblies and components Large Warm and Hot Cells (referred to as shops because of their size) provide the capabilities for handling the large assembled components, while smaller Hot Cells have the capabilities for a more detailed and even microscopic disassembly and examination of radioactive components A Decontamination Facility is located in the same building complex as the Hot Shop A Water Pit is provided for the interim storage and handling of fuel elements or other radioactive reactor components and assemblies Material can be placed directly into the Water Pit from inside the Hot Shop without any exposure to personnel

The information contained herein briefly describes these Warm and Hot Cell facilities, summarizes their functional and programmatic capabilities, and identifies the nuclear safety attributes of the facilities including their locations and nuclear materials safeguards and security measures

a This work is administered by the United States Department of Energy (DOE) Idaho Operations Office under DOE Contract No DE AC07 76ID01570

Warm and Hot Cell Facilities

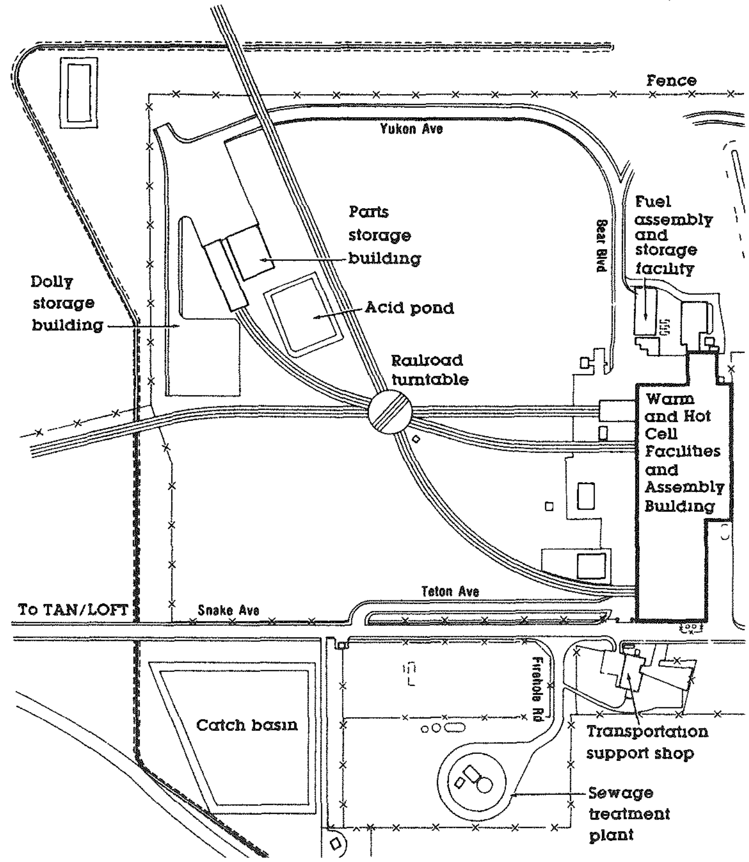
The Warm and Hot Cell facilities operated by EG&G Idaho, are located in three areas at the INEL A Warm Shop, Hot Shop, Hot Cell, Water Pit, and Decontamination Facility are located at Test Area North (TAN) Three individual Hot Cells are located at the Test Reactor Area (TRA) Two Hot Cells are located at the Auxiliary Reactor Area (ARA)

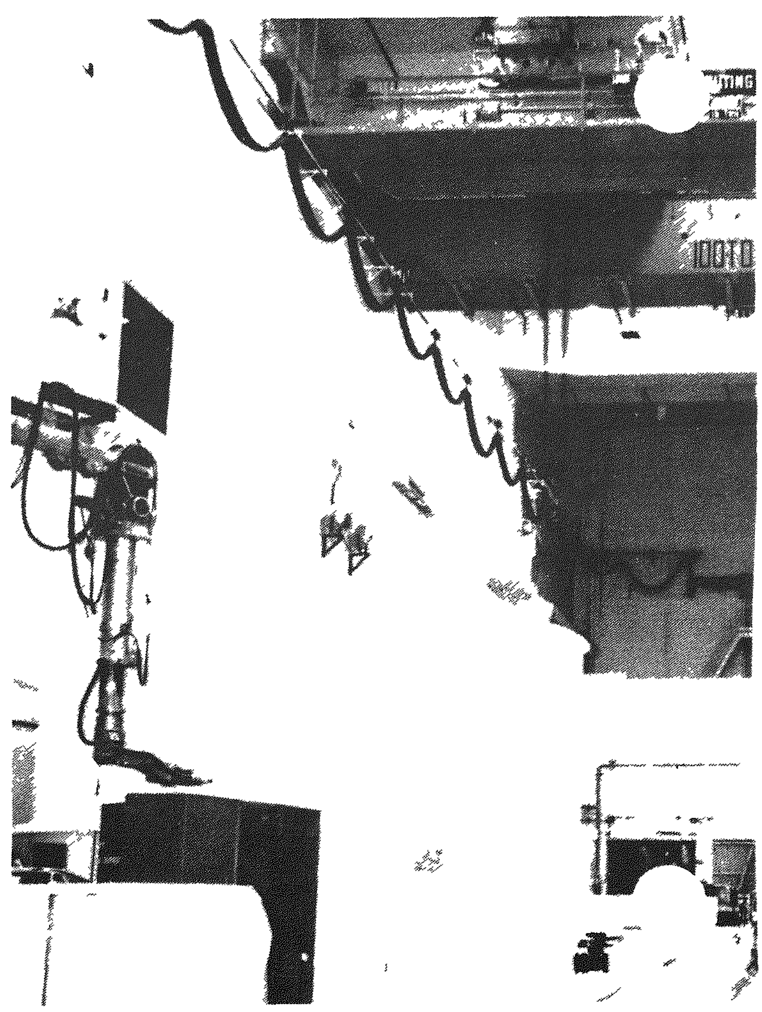
Warm Shop

The Warm Shop, located in the building immediately adjacent to the Hot Shop, provides direct contact handling of assemblies and components with low to medium levels of radiation and/or contamination This shop is one large open room measuring approximately 3200 ft^2 by 50 ft high It has a main entrance door measuring 27 ft wide by 33 ft high It is served by a 30/5-ton overhead traveling bridge crane The necessary craft personnel and equipment are located nearby for convenient utilization A four-rail track system connects this shop to the Hot Shop and to support facilities at the TAN area

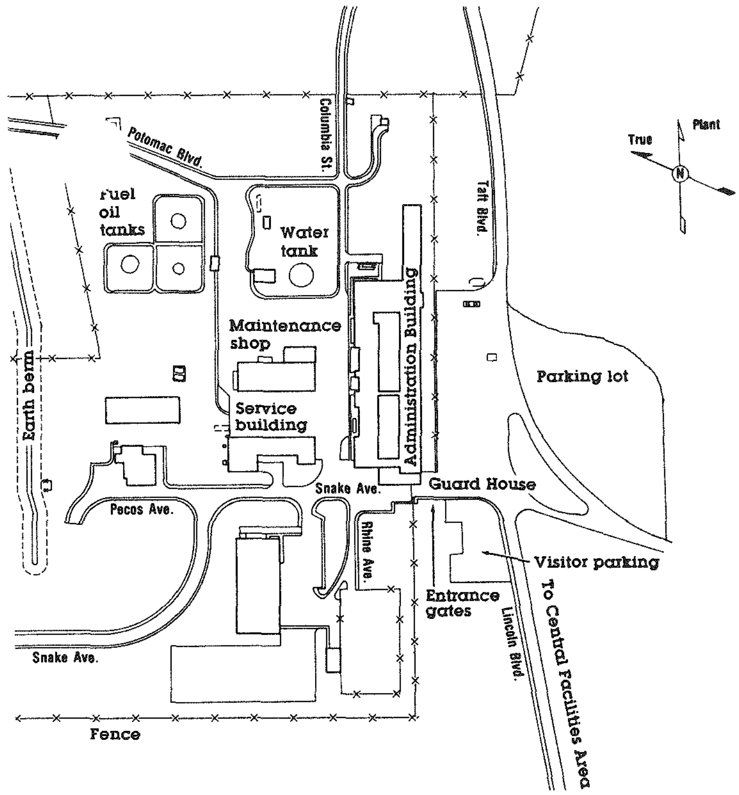
Hot Shop

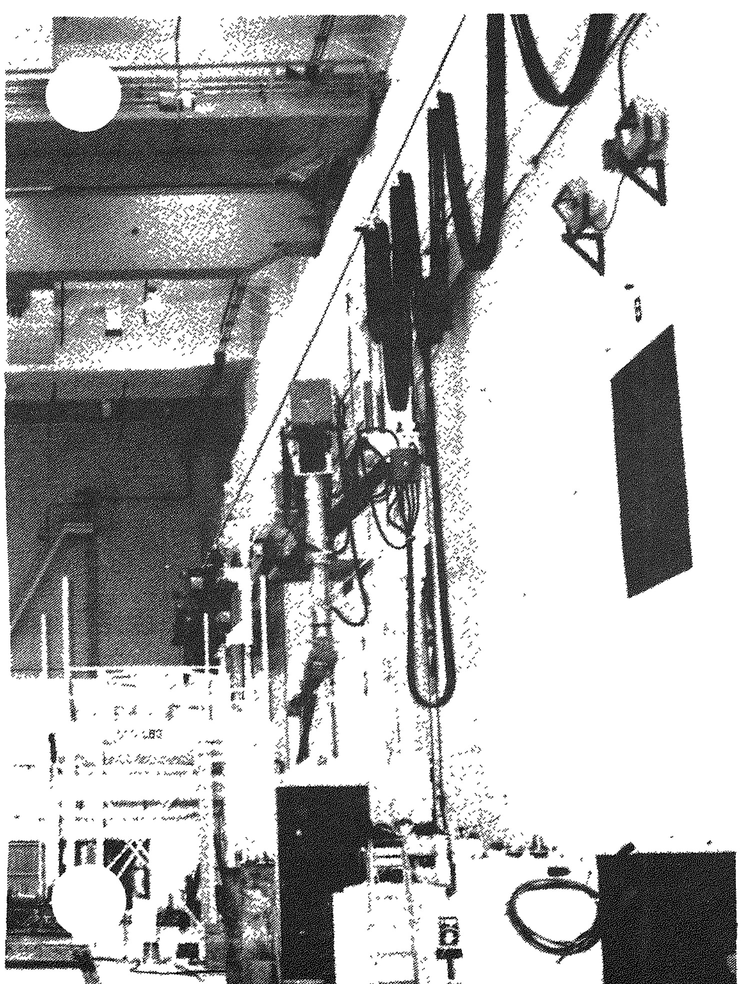
The Hot Shop, reputed to be the world's largest, measures 51 ft wide by 165 ft long by 55 ft high Its 7-ft thick walls and 6-ft thick windows afford protection to personnel involved in examination, handling, analysis, or disassembly of





Inside the Hot Shop the support structure and work platform used for unloading and loading radioactive material transport and storage casks is shown at the right toward the rear of the shop The large tank structure a the left is a silo used for interim storage of radioactive materials



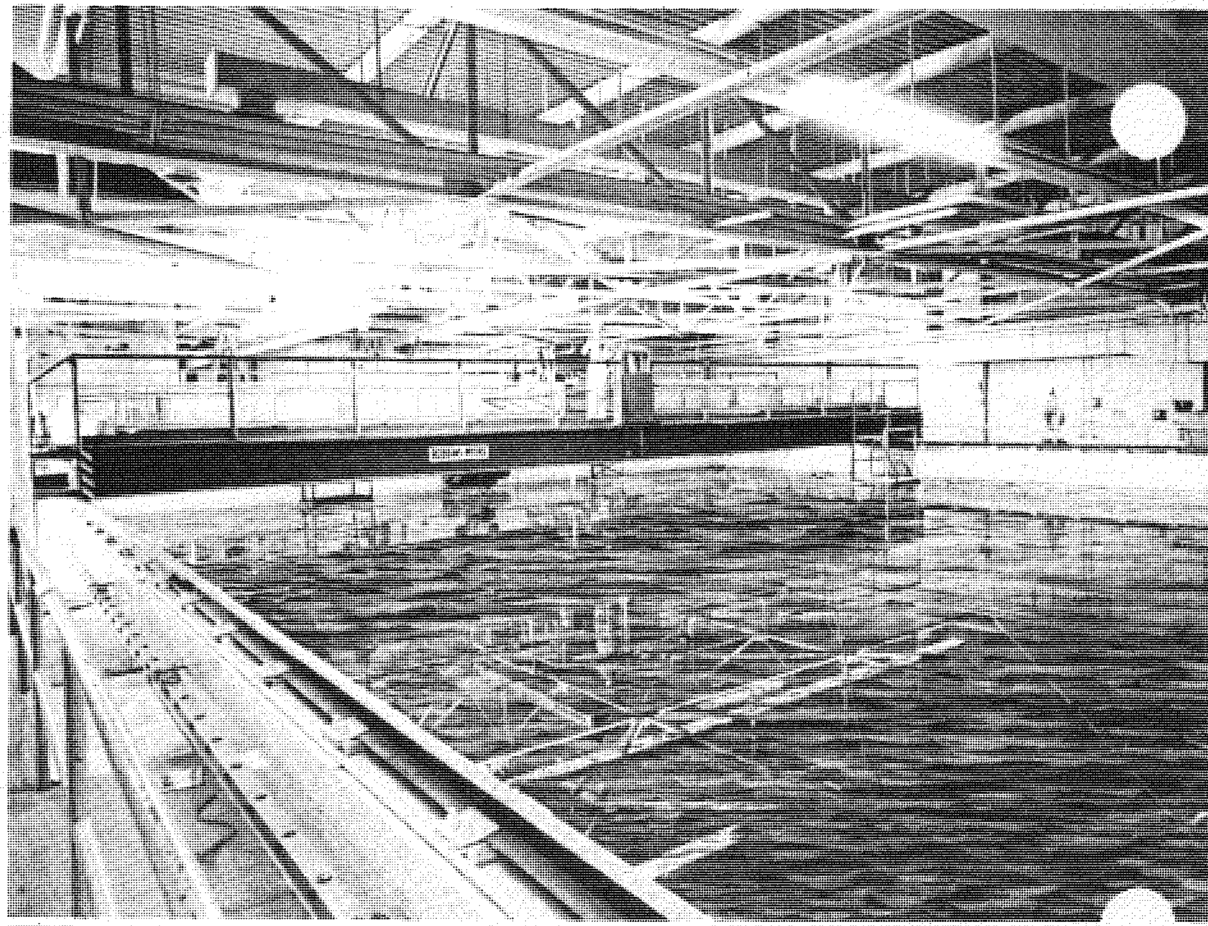


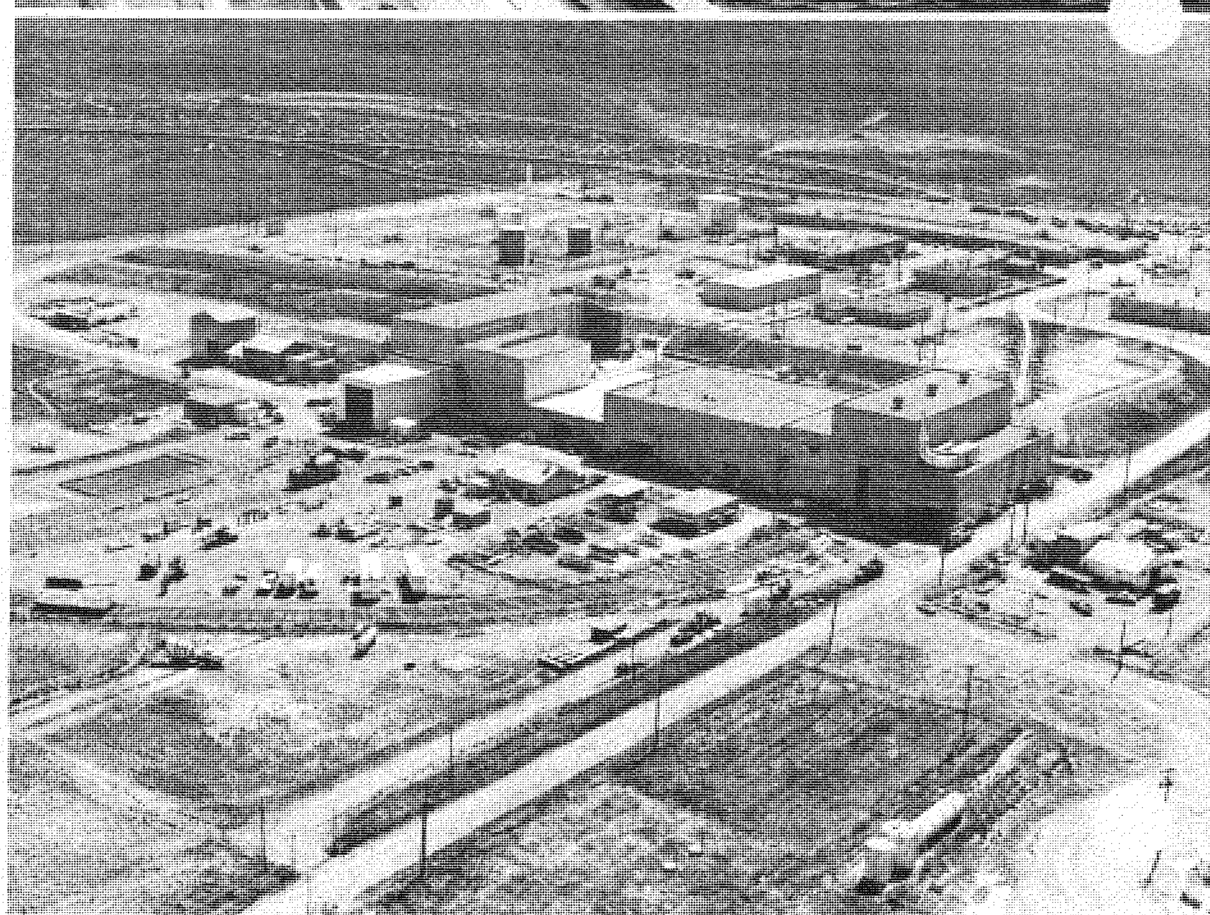
highly radioactive or contaminated assemblies up to and including complete reactor systems. Radiation levels up to 10^6 R (measured at 1 ft) have been safely handled.

Visual access to the Hot Shop is gained through a series of 6-ft thick windows arranged and installed on either side of the shop and in two rows corresponding roughly to second and third story heights. Binoculars, mirrors, periscopes, and closed circuit television are all used to enhance the visual observation and control of the remote functions within the Hot Shop. At each window is located a control pedestal for controlling the functioning of the crane and the pertinent manipulators. All of the stations on a given side and level are housed in a common "operating gallery."

The entire Hot Shop area is served by a 100/10-ton overhead, remotely controlled, traveling bridge crane. This crane, which can be controlled from any of the windows as well as from the Hot Shop floor, has a maximum lift height of 51.28 ft. Mounted immediately below the crane and covering generally the same floor area is a traveling overhead manipulator (O-Man). The O-Man includes a 5000-lb crane hook with a lift height of 30 ft, as well as the manipulator arm and hand rated at 500 lb.

In addition to the overhead manipulator facilities, there are three wall-mount manipulators. These are mounted on a vertical sliding track to give vertical coverage from 0 to 30 ft above the floor. Telescoping tubes extend the reach to the center of the Hot Shop. The combination of wall mounted and overhead manipulators gives remote working access to all areas within the Hot Shop. One 60-ton turntable, 17-1/2 ft in diameter, is set approximately flush in the floor to rotate large fixtures and equipment components for convenience of remote assembly or disassembly by the wall mounted and overhead manipulators.





Top: The large Water Pit is used to store radioactive materials and reactor fuel assemblies.

Bottom: Aerial view of the building complex housing the Warm and Hot Cell facilities at TAN.

Radioactive assemblies or materials contained in shielding casks are moved into or removed from the Hot Shop through a 27 ft 10-1/2 in wide by 33 ft high doorway The assemblies and casks are transported on truck trailers or railroad flatcars moved by a shielded locomotive on a four rail track system The doorway is closed by two 4-ft thick, staggered joint, biparting concrete doors mounted on rollers

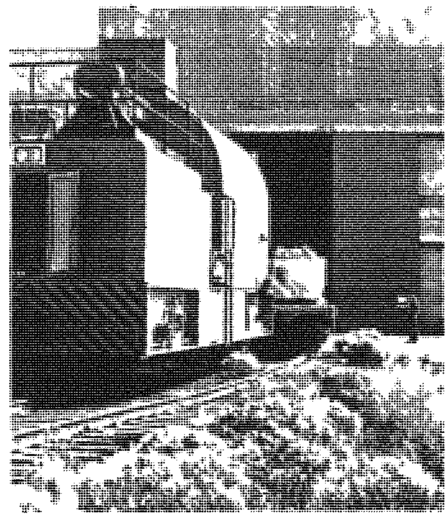
Water Pit

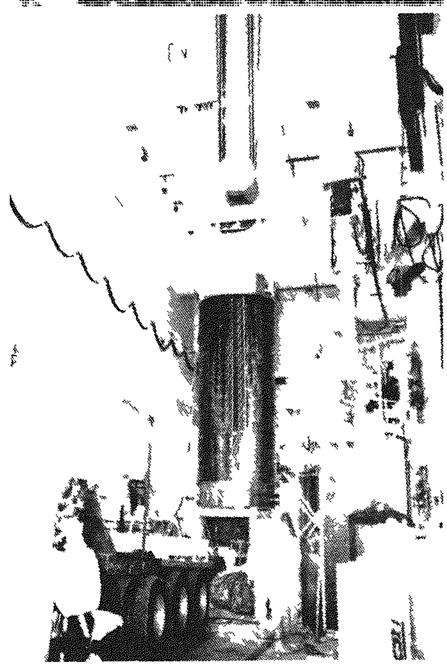
The Water Pit is 48 ft wide by 70 ft long is located adjacent to the north side of the Hot Shop, and is used for the storage of radioactive materials and "hot" components Access to the Water Pit is through the vestibule which extends under the shielding wall and into the Hot Shop Materials are lowered by means of the overhead manipulator or cranes onto the cart located in the bottom of the vestibule This cart is then winched into the Water Pit storage area

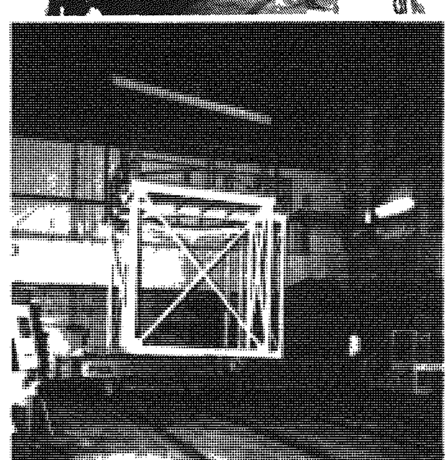
Access from the INEL road system is provided by a 30-ton tram hoist which can carry a shielding cask or comparable load from the truck bed and into the Water Pit A 15-ton monorail serves to transport material from the pit to the Hot Cell for detailed examination In addition to the above, a 15-ton overhead traveling bridge crane is availa ble to serve the entire area of the Water Pit

TAN Hot Cell

The TAN Hot Cell is located adjacent to the east end of the Hot Shop and is accessible through a shielding door This is a shielded room measuring 10 by 35 ft with five shielding, viewing windows Each viewing window is fitted with master slave manipulators which, in turn, are complemented by two overhead manipulators with 2-ton chain hoists serving the full length of the Hot Cell The necessary optical examination, and testing devices for detailed and optical analysis of medium-sized components and subassemblies are installed as required







Top: A specially constructed diesel locomotive is capable of moving heavy radioactive loads on flatcars while providing protective shielding for the locomotive operator

Middle The 100-ton overhead bridge crane moves the large radioactive material transport casks inside the Hot Shop

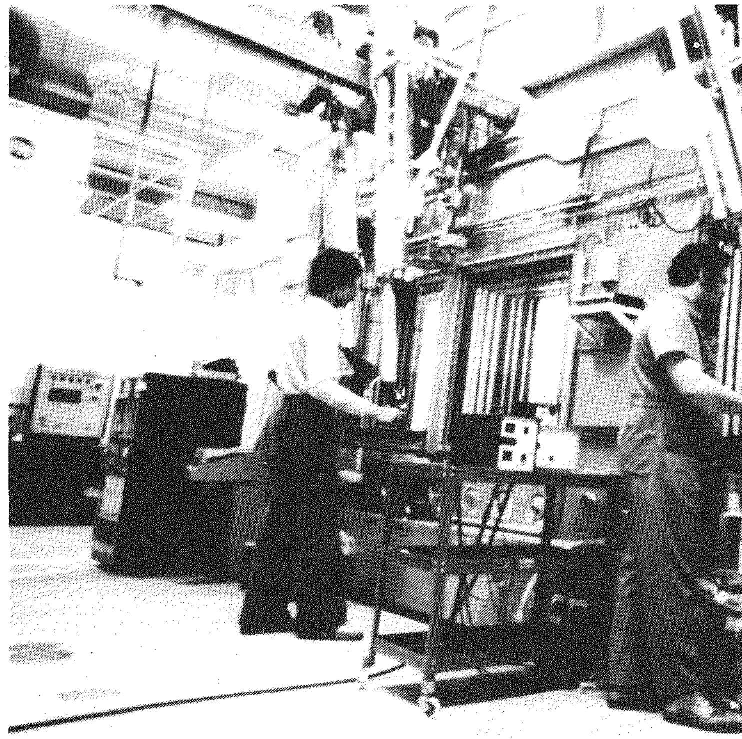
Bottom. The Warm Shop provides direct contact handling of assemblies and components with low to medium levels of radiation and/or contamination.

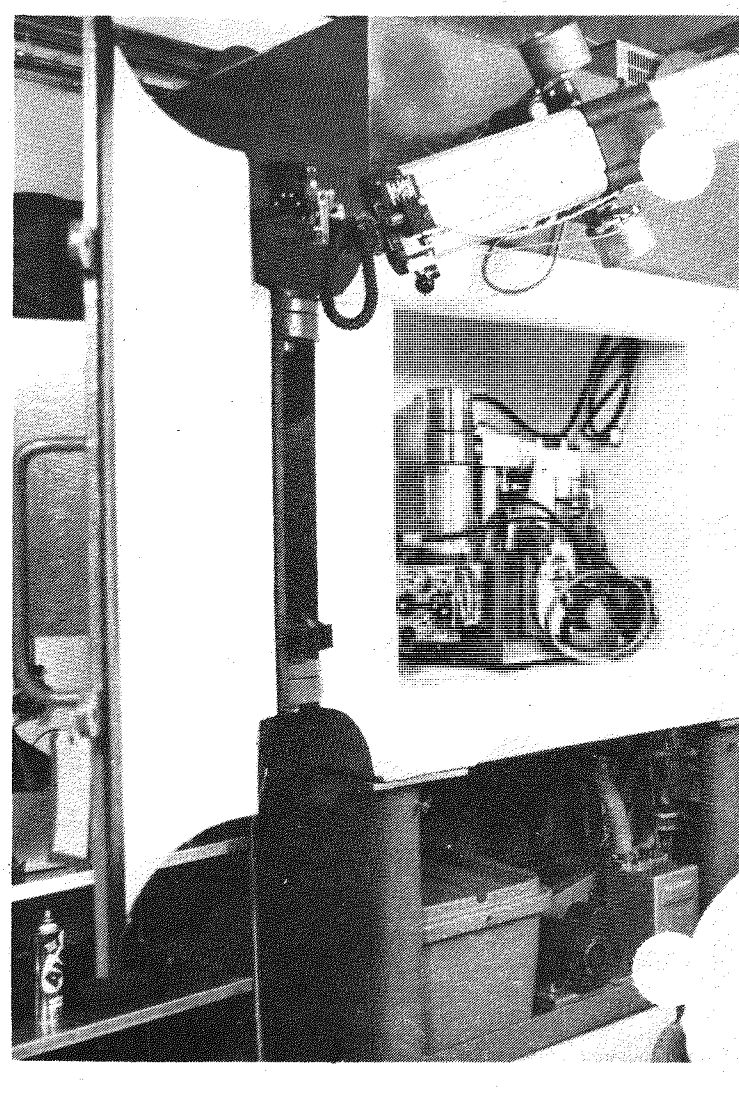
TRA Hot Cell Facility

The TRA Hot Cell Facility consists of three individual Hot Cells rated primarily for beta-gamma radiation work, but capable of accepting minor levels of alpha contamination by special arrangement. Radioactive metallography is performed at the TRA Hot Cells, with one cell equipped specifically for this work. This cell is provided with preparation equipment for sample mounting, grinding, polishing, cleaning, and etching. Two shielded metallographs and a scanning electronic microscope are available. Ancillary equipment includes a monocular and stereoscopic periscopes (both with photography capabilities), thin sectioning saws, vacuum impregnation equipment, and other pertinent sample preparation and examination equipment.

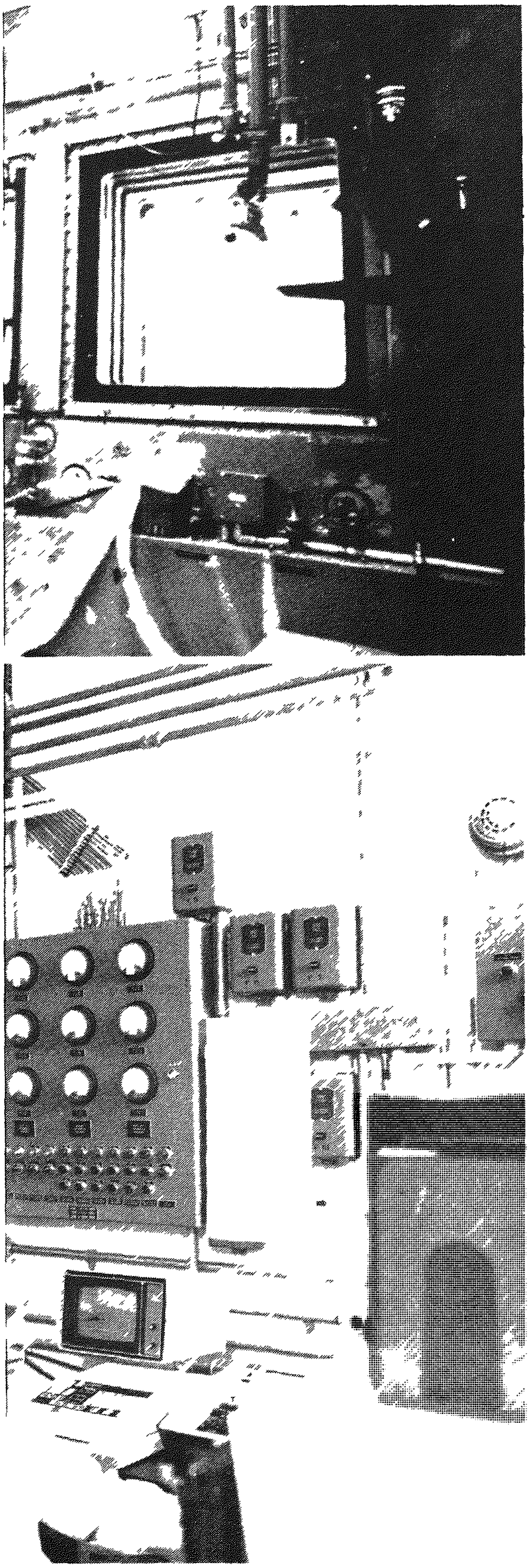
The scanning electron microscope was designed to provide continuously variable magnification from 9X to 300,000X, with a resolution of 70 angstroms. The specimen chamber is 5 by 5 by 4-1/2 in., with a goniometer stage providing motion in three dimensions plus rotation and tilt. An energy dispersive x-ray analyzer is included for element identification.

Sectioning of parent metals for samples is usually performed in a separate Hot Cell to maintain the cleanliness standards necessary for superior metallography. Capabilities include fuel rod encapsulation and impregnation for stabilization purposes, cutting by diamond or abrasive saw, plate or sheet punching for samples, high-speed or low-speed thin sectioning (wafering), and preparation of unique samples by machining and grinding.

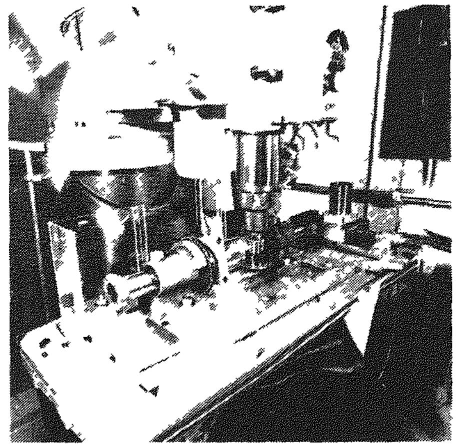


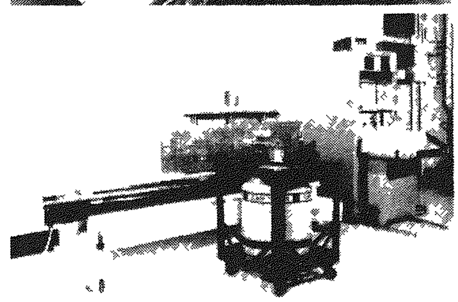


The technicians above are operating one of the three TRA Hot Cells.



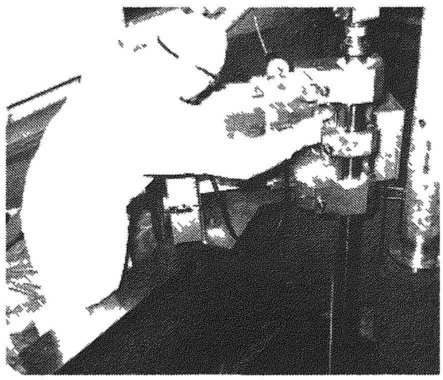
The scanning electron microscope is shown inside the Hot Cell cave with the shielding door open. The energy dispersive X-ray spectrometer, also shown, analyzes the output from the microscope

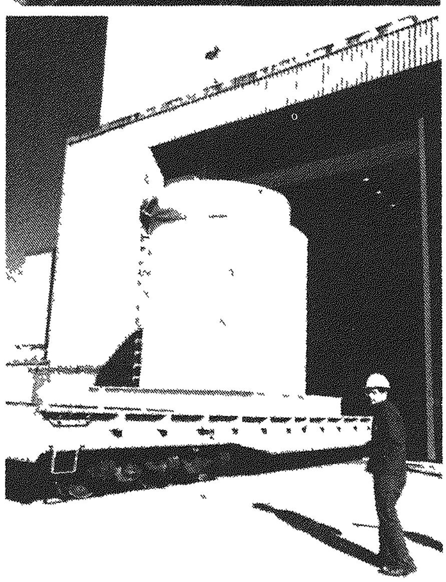




Top. Specimens are cut inside a Hot Cell using this remotely operated milling machine

Bottom. Gamma scanner used for isotopic and gross gamma scanning inside a Hot Cell.





Radioactive materials are received in the Hot Shop in a variety of specially designed shipping casks The technician in the center photo is preparing Hot Shop equipment for a nondestructive examination of a fuel bundle used in a reactor safety test conducted at the INEL

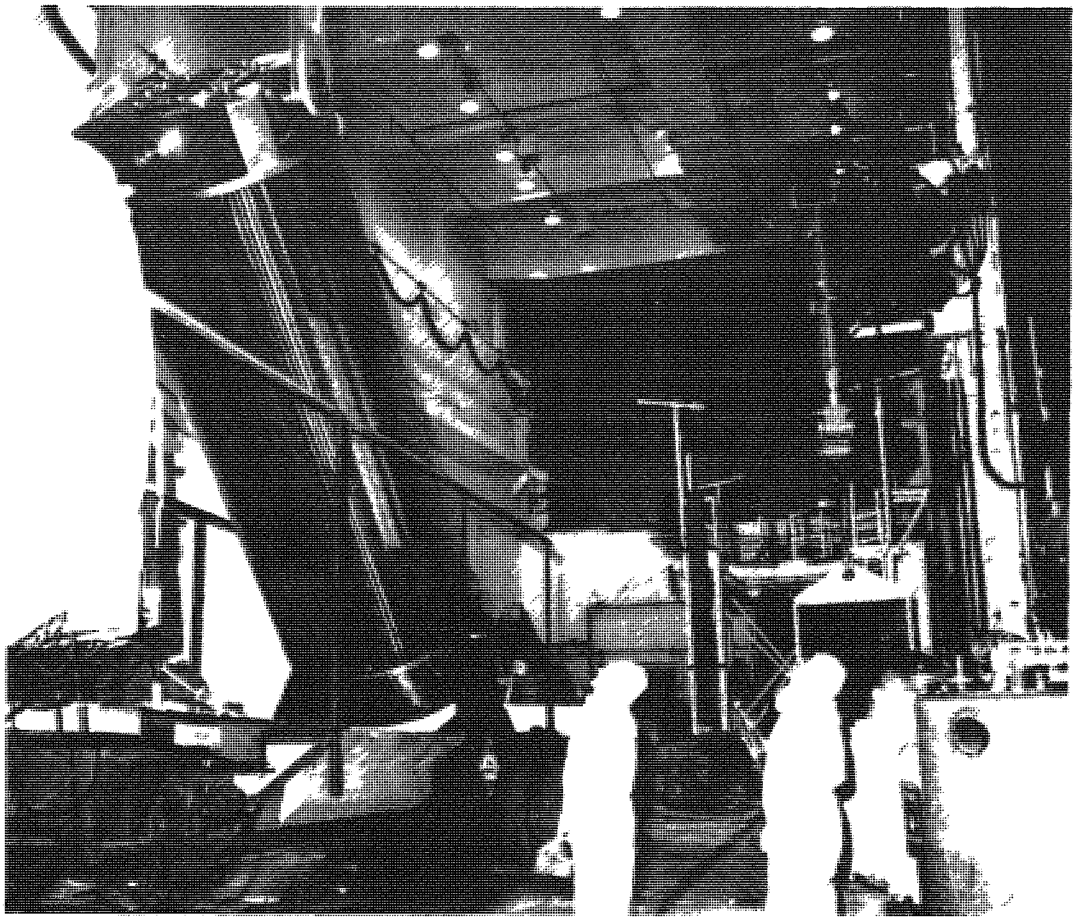
ARA Hot Cells

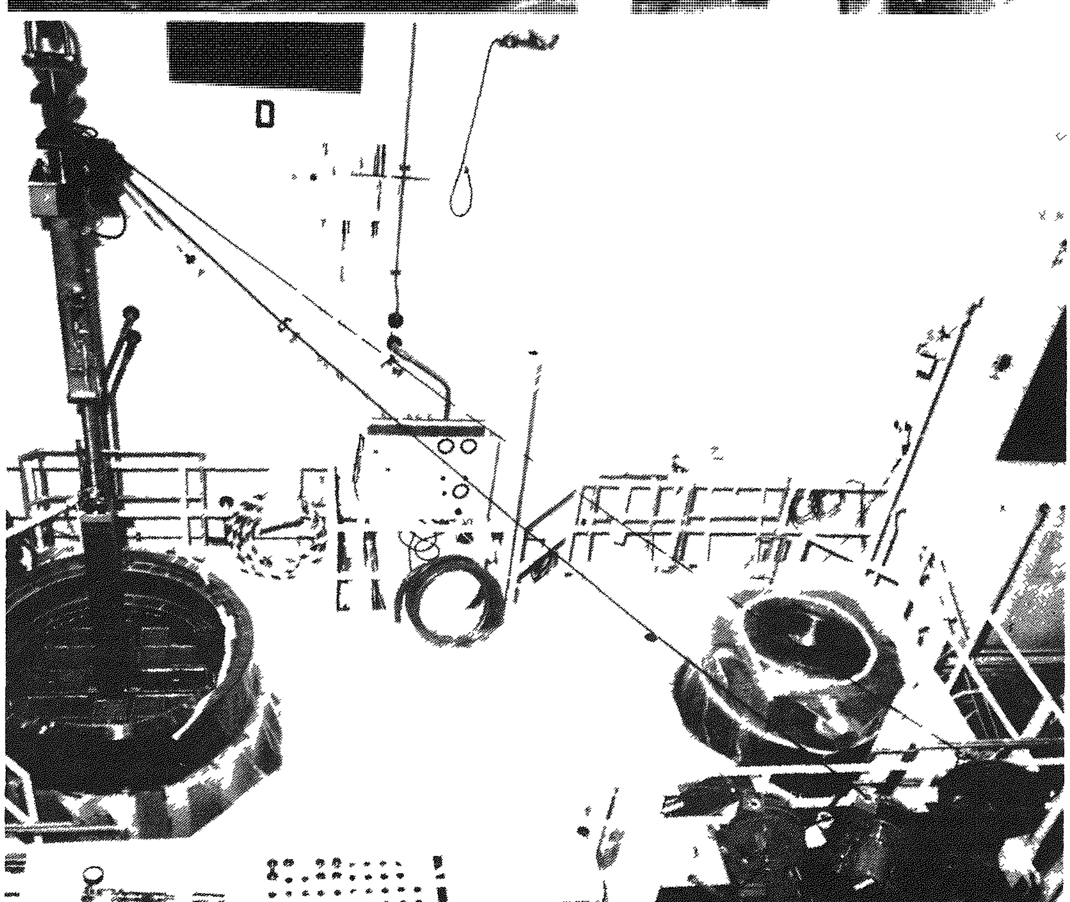
The ARA Hot Cells are used for nondestructive and destructive examinations and preparation or staging of radioactive items scheduled for examination in TRA Hot Cells. As with all other Hot Cells, ARA is equipped with remote handling devices. The ARA also has a metallograph to examine cold to warm radioactive samples.

Decontamination Facility

The INEL Decontamination Facility is conveniently located in the same building complex as the Hot Shop. The Decontamination Facility consists of a room with 1400 ft^2 floor area and 30 ft high. An overhead traveling bridge crane rated at 30 ton and with a 20-ft total lift services the entire area. The floor is lined with stainless steel. There are three stainless steel decontamination tanks measuring 6 by 6 by 4 ft, and three tanks measuring 3 by 3 by 4 ft. Various acids and caustics can be used as necessary to decontaminate almost any material. The tanks are lined with a plastic to prevent the particular acid from attacking the tank itself

The Decontamination Facility has been successfully used to decontaminate reactor components, casks, vehicles, Hot Cell handling equipment, and other assemblies in preparation for their storage, shipment, or for direct contact handling





Top. The large casks used to transport spent reactor fuel are transported to the INEL on a railroad flatcar, transferred to a truck trailer and moved into the Hot Shop. Here the cask is being removed from the trailer to be positioned in the support structure for unloading.

Bottom. Inside the support structure nuclear fuel and radioactive materials are remotely removed from the transport casks and are placed either in the Water Pit or in other casks for storage.

Facility Capabilities

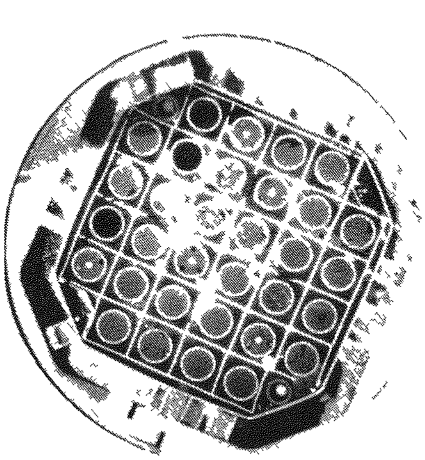
The EG&G Idaho Hot Cell facilities provide considerable capabilities for specifying, performing, analyzing, and reporting results of tests and examinations on nuclear reactor fuel and components and for preparing radioactive reactor components for storage and disposal

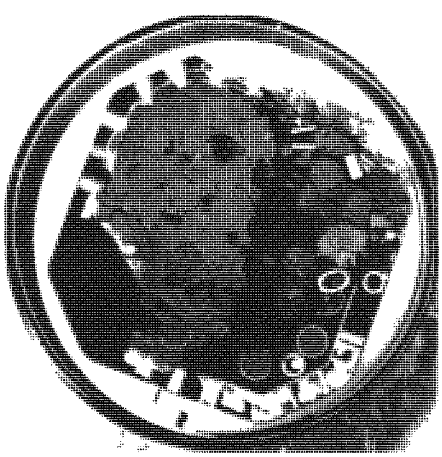
Posttest Examinations

Nuclear reactor fuel and components have been examined from a variety of sources and programs both from the United States and abroad, such as, commercial power reactors, high flux test reactors, and highly damaged fuel from reactor safety tests conducted at the INEL. This work has involved examining zircaloy-clad UO_2 fuel rods, uranium-aluminum fuel plates, UO_2-ZrO_2-CaO ternary fuel, and primary system filters and reactor core samples from the damaged Three Mile Island—Unit 2 (TMI-2) nuclear power reactor.

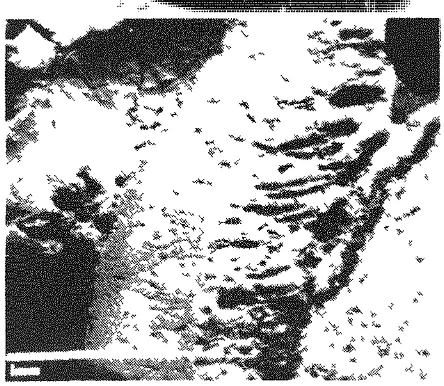
The examination objectives have concentrated on the investigation of high temperature material interactions and fission product distribution Fuel rod and fuel plate damage, UO_2 fuel restructuring and melting, UO_2-zircaloy reactions, fission gas redistribution, and the fissile and fission product contents of particulates have been studied Techniques employed are as follows

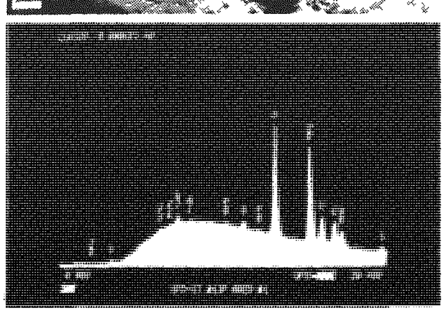
- Nondestructive measurements such as photo-visual documentation, dimensional measurements, spectral gamma scanning, and neutron radiography and tomographic reconstruction
- Destructive examination involving remote optical metallography and remote scanning electron microscopy
- Special handling, cutting, and sample preparation techniques to accommodate the variety of fuel designs, including epoxy-encapsulation of a 3-ft long, 32-rod experimental fuel bundle.





Top two: Cross sections of fuel bundles are prepared and examined in the Hot Cells to provide results for the severe fuel damage tests conducted at the INEL. These examples compare the extent of damage at two elevations in a 5-in. outside diameter test fuel bundle



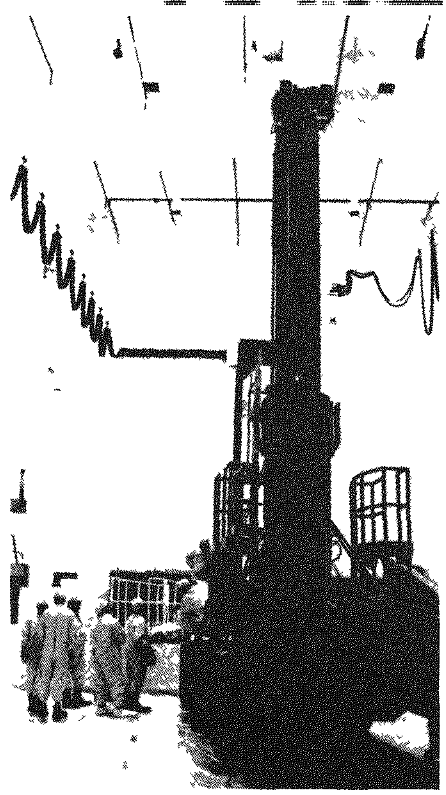


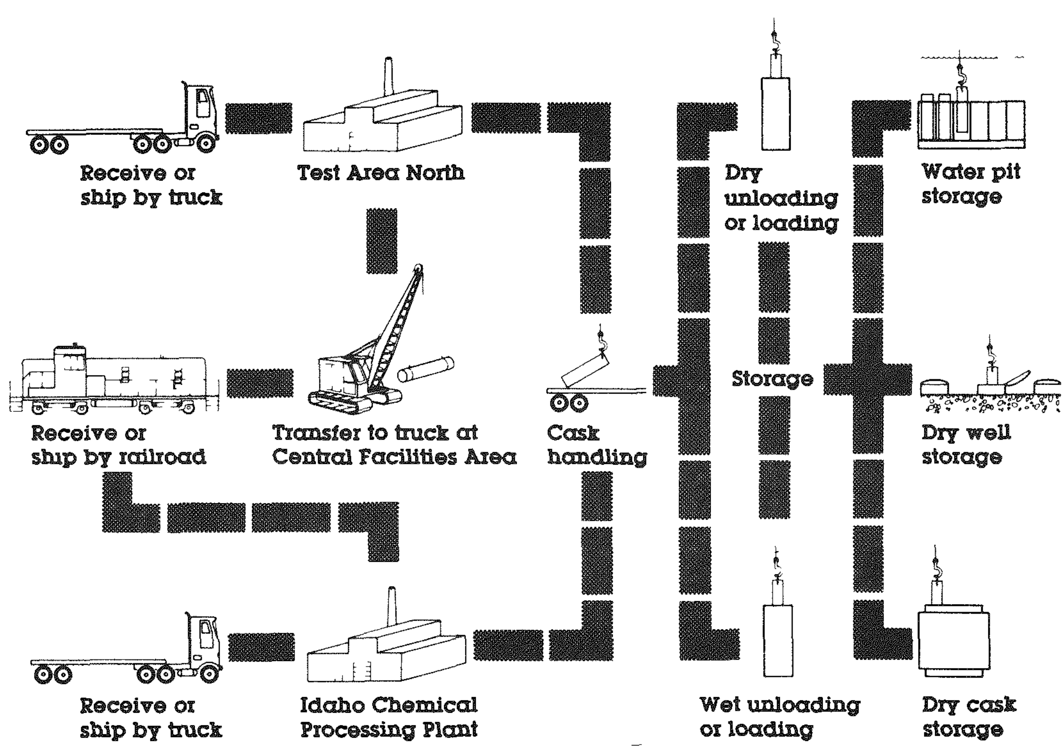
Bottom two: These examples show a macrophotograph of a sample surface enlarged to 40X by the scanning electron microscope, followed by an elemental analysis of the sample performed using the energy dispersive X-ray spectrometer

Testing and Processing

Equipment and waste products from the damaged TMI-2 nuclear power reactor are being processed in the Hot Shop for permanent disposal or for storage. The EPICOR-II ion exchange resin liners (50) were received in the Hot Shop, loaded and sealed into high integrity containers, and shipped to a permanent burial ground in Washington state. Canisters containing the core debris from TMI-2 will be received in the Hot Shop and stored in the Water Pit.

Dry fuel storage concepts are being tested and evaluated in the Hot Shop and Hot Cell facilities Fuel rods were subjected to a long-term, low-temperature behavior test in the Hot Shop to provide the United States Nuclear Regulatory Commission with information to assist in licensing dry fuel storage for light water reactor spent fuel Posttest examinations were performed in the TRA Hot Cells. Cask testing and fuel transfer and consolidation work has been initiated in the Hot Shop to support the development and demonstration testing of dry cask storage for spent fuel from pressurized water reactors.

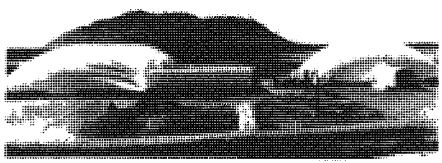


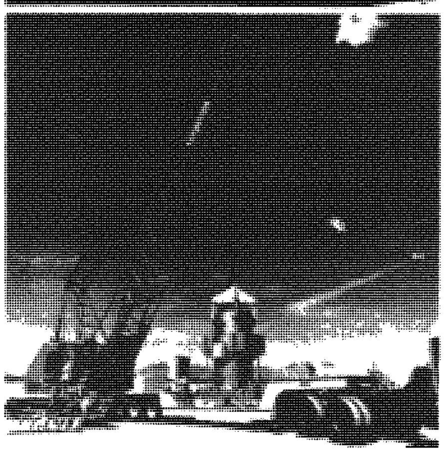


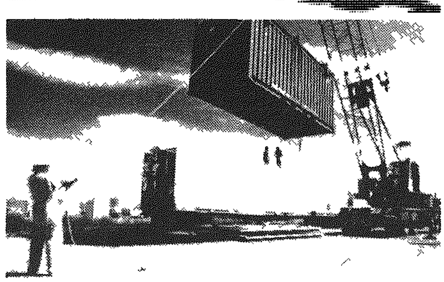
Top: Remote-cask sealing operations conducted in the Hot Shop

Middle: Hot Shop technicians prepare to unload an irradiated fuel bundle from a specially designed transport cask.

Bottom: EG&G Idaho's Warm and Hot Cell facilities are an integral part of the INEL's spent reactor fuel and waste handling capabilities







Top: Idaho Chemical Processing Plant at the INEL.

Middle: Radioactive Waste Management Complex at the INEL.

Bottom two: Offloading specially designed radioactive waste containers at the RWMC

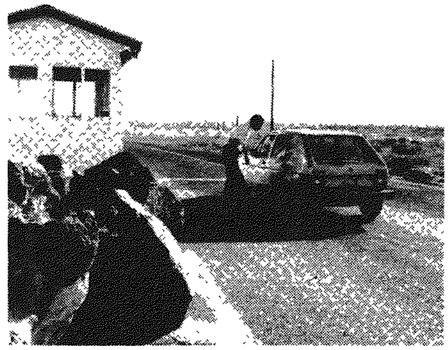
Facility Siting

As discussed earlier, the Hot Cell facilities operated by EG&G Idaho are located at the INEL. The INEL comprises some 571,800 acres, or 894 square miles, of sagebrush-covered land in southeast Idaho At this location, the INEL provides an isolated, controlled Site where various types of nuclear reactors or facilities can be tested and operated The remoteness of the INEL makes it an ideal location for siting nuclear facilities with respect to population consideration The INEL is isolated because of the large exclusion area of the Site itself, and also because the population centers in the surrounding region are very low density and are not located in the predominant downwind directions (north and northwest)

The security of the Site and of the facilities and equipment located thereon is protected by a permanent, well trained and equipped security force Operations involving nuclear materials at the Hot Cell facilities are performed, monitored, and controlled according to procedures and limits approved by the DOE. These limits ensure that criticality and radiological safety requirements are maintained.

The isolation and security of the INEL allows nuclear materials to be protectively stored or disposed of at the INEL. Radioactive materials designated as waste can be disposed of at the Radioactive Waste Management Complex, operated by EG&G Idaho Spent nuclear fuel from military, as well as research reactors, can be reprocessed in the Idaho Chemical Processing Plant (ICPP), operated by Westinghouse Idaho Nuclear Company. The ICPP includes facilities for receiving and storing spent nuclear fuel, reprocessing the fuel, treating wastes generated by reprocessing, and storing the treated wastes.

Transportation of radioactive assem-
olies and materials contained in casks
s safely accomplished between the
Hot Cells and other facilities at the INEL
over a combination of roads and rail
rackage. EG&G Idaho has developed
considerable experience and exper-
ise in the design and fabrication of
shipping casks and transporters.



Top: The security force checks personnel and vehicles entering the INEL and constantly monitors sensitive areas inside INEL facilities.

Bottom: The large exclusion area of the INEL and its location in southeast Idaho where the population centers in the surrounding region are very low density, make the INEL an ideal location for siting nuclear facilities.

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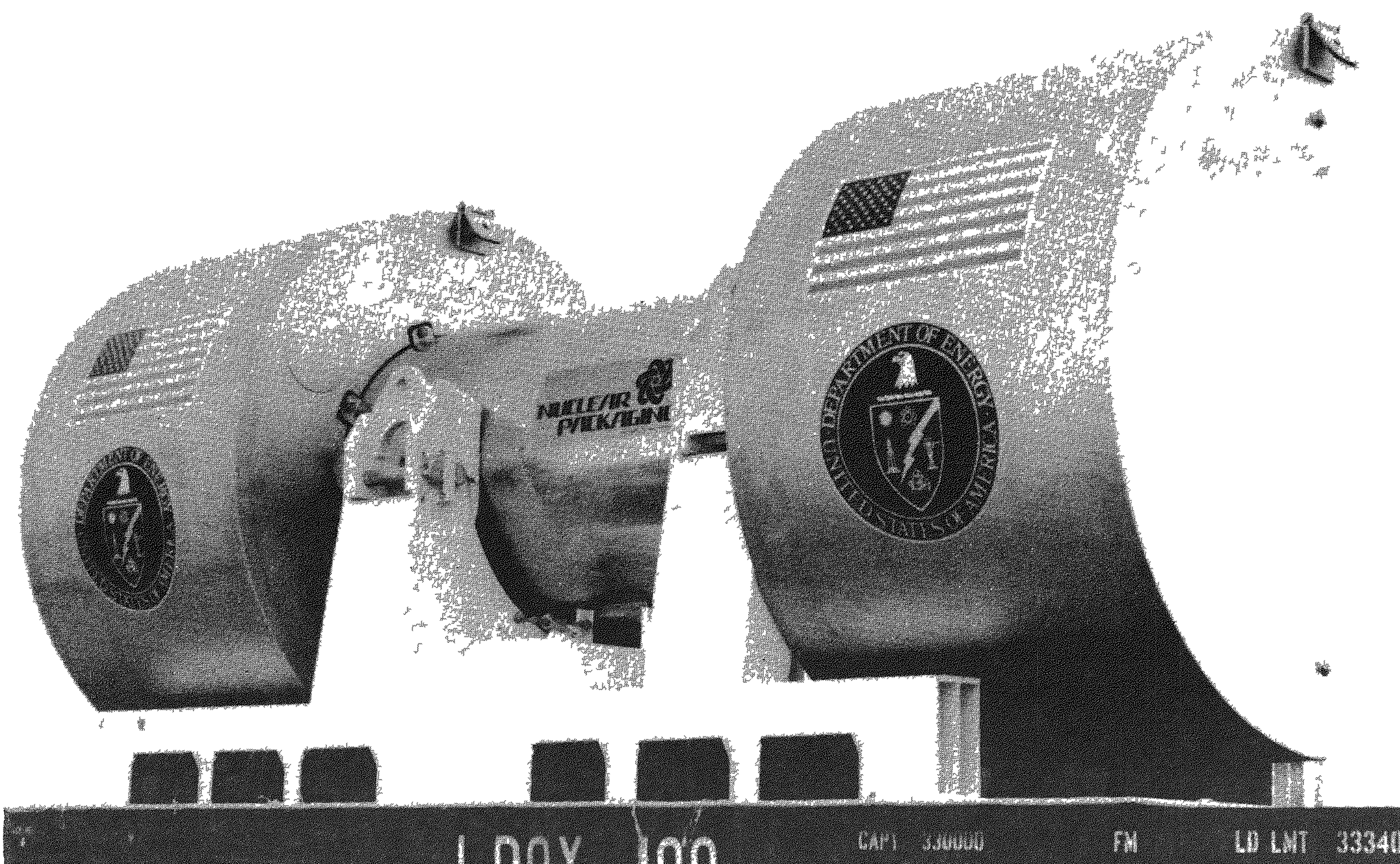
TMI Unit 2 Technical Information & Examination Program

UPDATE

Volume 6, Number 1 April 1986

Special cask in place on 150-ton railroad car.

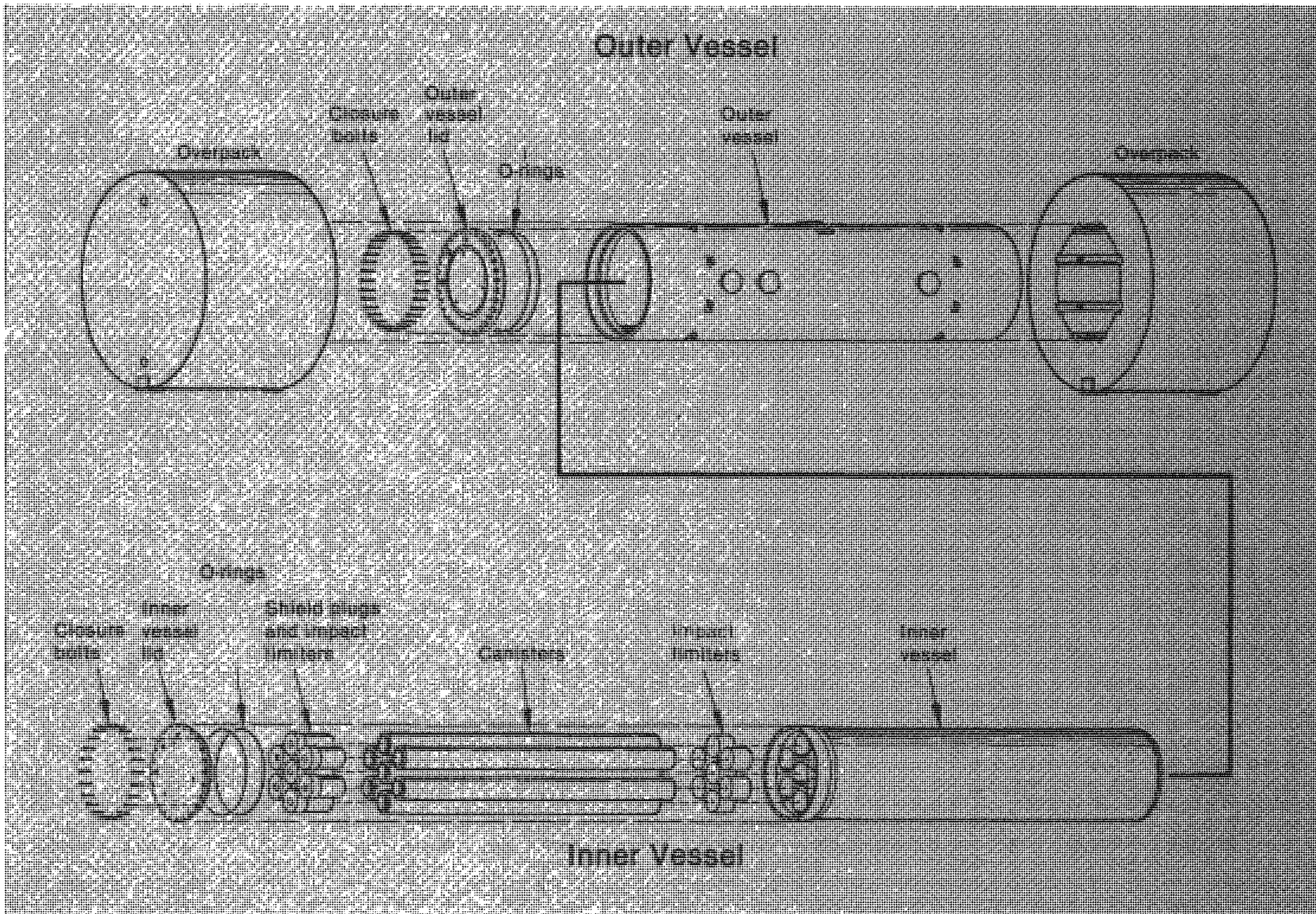


One of the remaining major efforts in the cleanup of the Three Mile Island Unit 2 reactor was the development of a safe, reliable shipping cask to transport the TMI-2 spent fuel debris from TMI to the Idaho National Engineering Laboratory

*Included in this special issue of the **Update** are articles about design and construction of the shipping cask, the extensive testing process for cask certification, procedures for loading the core debris at TMI-2, the transportation process and safety precautions, and plans for unloading, storing, and examining the fuel debris at the INEL*

Published by EG&G Idaho, Inc., for the U.S. Department of Energy

Special Cask Developed for Core Debris Shipments



Exploded view of the rail cask outer and inner vessels.

In 1984, the Department of Energy (DOE) signed a contract with GPU Nuclear Corporation to accept TMI-2 core debris for use in a research and development program aimed at understanding the accident sequence at TMI-2. DOE is taking the responsibility for transporting, storing, and ultimately disposing of the entire core. The first of more than 250 canisters filled with TMI-2 debris is expected to be delivered by GPU Nuclear to DOE in mid-1986; the shipping program is expected to last two to three years.

During the planning stages for handling core debris, EG&G Idaho (a DOE prime contractor at the Idaho National Engineering Laboratory) investigated spent fuel shipping cask options. The requirements for TMI-2 debris transport led to the decision that new casks be designed, certified, and fabricated for this unique project rather than modify and recertify existing casks. EG&G Idaho also evaluated whether canisters should be transported by truck or rail.

While truck-mounted casks could transport one to three fuel canisters each, the use of a rail cask that holds seven canisters has significant advantages. With more canisters in a rail cask than in a truck cask, fewer shipments will be needed. Only 35 to 40 rail shipments will be required, compared with the potential for more than 250 truck shipments.

Fewer shipments reduce the chance for an accident involving the cask during the transportation sequence and thereby reduce the total risk to the public. In addition, fewer shipments mean fewer loading and unloading operations and reduced radiation exposure to workers. For the overall TMI-2 shipping operation, the use of rail casks is projected to be more efficient and less costly than if truck casks were used.

The choice of rail to transport the TMI-2 core debris led to the development of the Nuclear Packaging, Incorporated (NuPac) 125B rail cask. This cask was designed, tested, and fabricated specifically for transporting the TMI-2 spent fuel debris to the INEL. The cask was certified by the Nuclear Regulatory Commission (NRC) in April 1986.

When the cask design was started in late 1984, several unique factors about the condition of the TMI-2 spent fuel had to be considered. Existing spent fuel shipping casks are certified only for transporting assemblies of undamaged spent nuclear fuel. The NuPac 125B rail cask had to be certified to transport spent fuel debris from the TMI-2 accident. Without the cladding that surrounds the spent fuel in an intact assembly, two barriers are needed during transport to comply with NRC regulations.

Under NRC regulations a cask with two barriers is required. Each barrier is a specified containment boundary that must meet stringent requirements for structural strength and demonstrate that an uncontrolled release of the contents will not occur, even after a sequence of accident conditions.

This double containment in the NuPac 125B rail cask is accomplished by use of two separate and strong vessels, one inside the other, each with a thick lid and seals that will be leak tested before each shipment. In addition to the cask inner and outer containment vessels, there are canisters into which the fuel debris will be loaded underwater at TMI. These canisters are another barrier that prevents a release of material during transport. A complete shipping package includes the double containment cask and its canisters, making three levels of protection to ensure the safety of the public.

Leaktight Design

Another unique feature of the NuPac 125B rail cask is the extremely small rate of leakage of radioactive materials that is allowed after a sequence of serious accidents. Each of the two cask containment vessels was designed, built, and tested to a leakrate low enough that the term "leaktight" is applicable, even during and after hypothetical accident conditions.

The leakrate for leaktight is defined as one-tenth of one-millionth of a cubic centimeter of gas per second at a pressure difference of one atmosphere across the containment boundary. This leakrate is equivalent to about three cubic centimeters in a year, or a bubble growing to about the size of a pingpong ball. Only gas could escape...not radioactive particles.

This low leakrate applies for leakage from the inner to the outer containment vessel, as well as from the outer vessel to the environment. The canisters and containment boundaries in the rail cask will ensure that an uncontrolled release of material to the environment will not occur.

Another important design consideration in developing a safe shipping package for the fuel debris was the control of gases that are generated when radioactive materials are in contact with water. The radiation that is emitted splits nearby water molecules into hydrogen and oxygen gases by a process called radiolysis.

These gases must be controlled during transport of wet radioactive materials or a flammable gas mixture could result. The method of control for TMI-2 fuel debris shipments is to use a catalyst that recombines the hydrogen and oxygen gases into water and allows safe transport of the fuel debris.

One other important consideration in the rail cask design was ensuring that the nuclear fuel contents would remain subcritical under all conditions. Subcritical means that the self-sustaining splitting of atoms that occurs in a nuclear reactor cannot occur in the cask.

The rail cask and the fuel debris canister designs ensure subcriticality of the nuclear fuel. This feature—an overriding design consideration—led to the incorporation of criticality control structures into each canister and the inner containment vessel of the cask.

The criticality control materials are positioned and supported to ensure subcriticality of the nuclear fuel by absorbing neutrons needed to achieve a chain reaction. With these neutron absorbers, subcriticality is maintained even after the sequence of accidents is considered.

Inner Containment Vessel

Each cask consists of an inner containment vessel that fits into an outer containment vessel. The inner vessel is fabricated starting with a hub-and-spoke structure made of stainless steel plates that are welded together. This structure is welded to two large forgings at each end. The structure prevents the seven canisters and their supports, which fit into each opening in the structure, from crushing each other in impact accidents.

Each canister fits into a stainless steel tube that forms part of the containment boundary of the inner vessel. Each tube is welded at the bottom to a thick plate that seals the tube closed at this end. The containment boundary is completed with a massive forging to which the tubes are welded and the thick, stainless steel lid that is bolted to the forging.

The 5-inch-thick lid is bolted down with 24 3/4-inch-diameter bolts. Around the edge of the lid are two O-rings that form the bore seals, which are inspected and leak tested before each shipment.

In addition to the stainless steel plates that separate the seven containment tubes, there are one-inch-thick plates welded around the outside that stiffen the inner vessel and form voids between the plates and the outer surface of the containment tubes.

A neutron absorbing material that solidifies like concrete is pumped like grout into these voids. The neutron absorber ensures that the canisters remain subcritical and the strength of the material, together with the plates, protects the containment tubes from damage should an accident occur.

For added safety, another design feature is incorporated inside the inner vessel. Located at the end of the containment tubes are removable energy absorbers that protect the canisters by crushing under accident conditions. Each energy absorber is an aluminum honeycomb material that limits the axial impact forces on the canisters.

The upper energy absorbers are attached to the bottom of shield plugs—short, solid cylinders of stainless steel added for worker radiation protection. After canisters are loaded into the cask, the shield plugs reduce the radiation from the fuel debris to levels that allow workers to replace the inner vessel lid and test the seals.

Outer Containment Vessel

Like the inner containment vessel, the outer containment vessel has many safety features included in the design. The outer vessel is called a composite wall cask because there are three thick layers of metal that form the wall of the cask. Two layers are stainless steel shells, one inside the other, that have a gap of nearly four inches between them. Molten lead is poured into the gap between the shells. The molten lead pour is accomplished after a brick oven is built around the outside of the cask. The entire cask is heated to a temperature hotter than the melting point of lead and the molten lead is added. When the lead cools and solidifies, it becomes an effective shield to reduce radiation levels outside the cask to below acceptable levels. After controlled cooling of the cask, the shielding effectiveness of the lead is checked with a radiation source to ensure there are no voids in the lead.

The larger stainless steel shell is two inches thick, while the shell that fits inside is one-inch-thick stainless steel. Both shells are welded at the bottom to a thick base plate that is carefully machined to the correct dimensions for welding.

Both shells are also welded to a large upper forging of stainless steel that is machined to very precise dimensions where the outer vessel containment seal is formed. The 7.5-inch-thick lid is bolted in place with 32 1.5-inch-diameter bolts. Around the edge of the lid are two O-rings that form the bore seals, which are inspected and leak tested before each shipment.

Attached to the outer shell are thick, short cylinders of stainless steel that are used to lift or hold down the cask during use. These attachments, also known as trunions, are designed and tested to show that they can support more than the weight of the loaded cask.

Another attachment to the outer shell is a structure called the shear block. This attachment absorbs forces during transport that would jolt the cask forward or backward, and protects the trunions from high inertial loads which may be encountered during transport.

Another safety feature of the rail cask is a thermal shield that would help protect the cask in an accident involving fire. The thermal shield consists of a wire wrapped around the outer shell every couple of inches, covered by a thin sheet of stainless steel welded over the wire, leaving an air gap between the thin sheet and the outer shell. This air gap reduces the amount of heat that can flow into the cask body in a fire because air is a poor conductor of heat energy. The thermal shield and the high heat capacity of the cask would keep temperatures low inside the cask if a fire occurred.

One other structural safety feature gives the cask a dumbbell-shape appearance. Large energy absorbers, called overpacks, are attached to each end of the outer shell. Each overpack is made of a thin plate of stainless steel and filled with foam that crushes on impact, absorbing energy and protecting the cask body. The effectiveness of the overpacks was demonstrated by a series of drop tests, done as part of the cask certification process, that showed the safety of this cask design feature. (An article about the drop tests appears in this Update issue.) □

Special Canisters Designed to Hold Spent Fuel Debris

Three different types of canisters are being used to defuel the TMI-2 reactor. Each has the same general external appearance—a stainless steel vessel 14 inches in diameter by 150 inches long. All have features that ensure safety during transport inside the rail cask.

The first type of canister is called a fuel canister and has a removable upper lid. With the lid removed, there is a square opening into which damaged fuel assemblies with a full cross-section can be lowered.

The second type is a knockout canister and is used in a hydraulic vacuum defueling operation. Water and pieces of debris are vacuumed up with a tool and pumped through the inlet of a knockout canister. The pieces of debris settle out of the water as the flow velocity decreases in the relatively larger diameter of the canister. The water, with residual fine pieces of debris, leaves the knockout canister and enters the third type of canister—a filter canister. This canister captures the fine debris on pleated, 0.5-micron stainless steel filters.

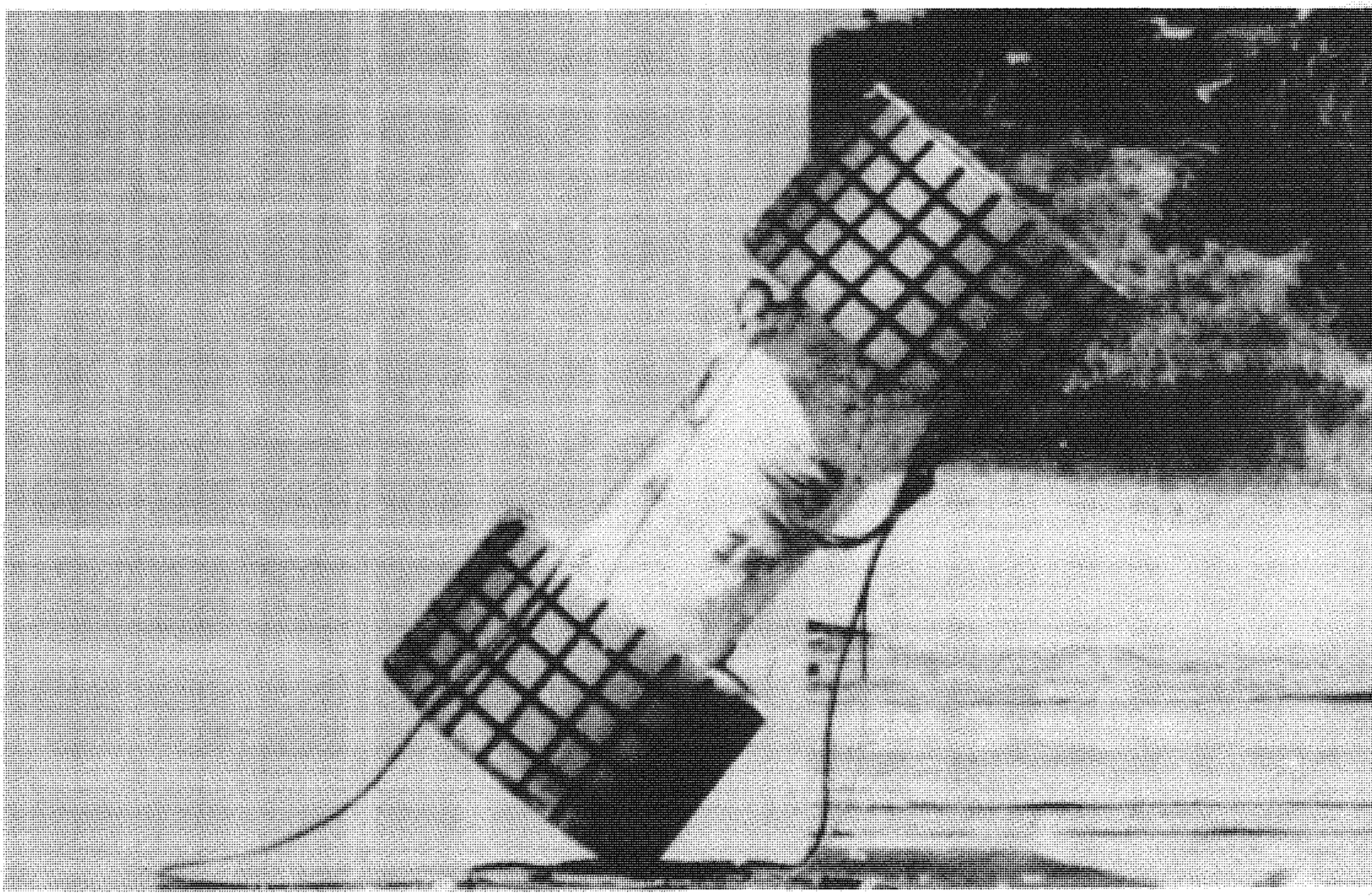
Neutron absorber materials are also built into all three canister types to ensure subcriticality of the nuclear fuel. In the fuel canisters, there is a square of borated aluminum sandwiched between two sheets of stainless steel. To ensure that the square does not move in an accident, lightweight concrete is added to fill the space between the outside of the square and the inside of the canister shell.

The neutron absorbers in the knockout canisters are located inside one large control tube and four small outer tubes. Each tube contains pellets of boron carbide that are seal welded inside. The tubes are supported along their length by thick plates that limit movement of the tubes.

In the filter canisters, the mass of the stainless steel filter media and a central tube of boron carbide pellets (as in the knockout canister) act as the neutron absorbers.

In all three types of canisters, both the upper and lower canister heads have beds of catalytic materials that recombine the radiolytically generated hydrogen and oxygen gases back into water and prevent the formation of combustible gas mixtures. □

Thorough Analyses and Tests Performed for NRC Cask License



Oblique drop at the instant before impact.

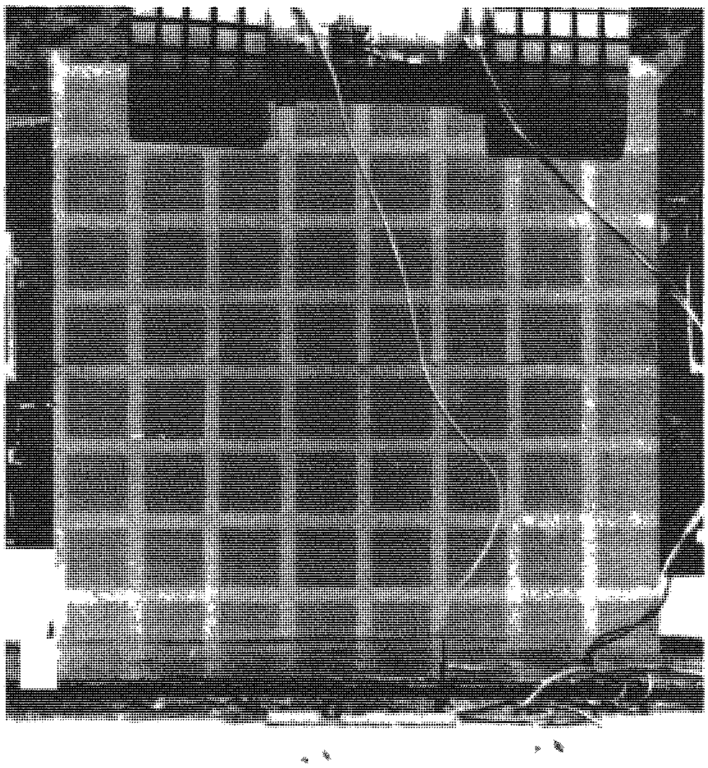
Obtaining certification from the NRC for the NuPac 125B rail cask required thorough analyses of the cask structures, thermal behavior, containment capability, shielding performance, and controls that ensure subcriticality.

The certification for the rail cask is based on an extensive three-volume safety analysis report. The report contains both the results of computer analyses and data from drop tests that were performed to demonstrate the structural integrity of the cask and canisters.

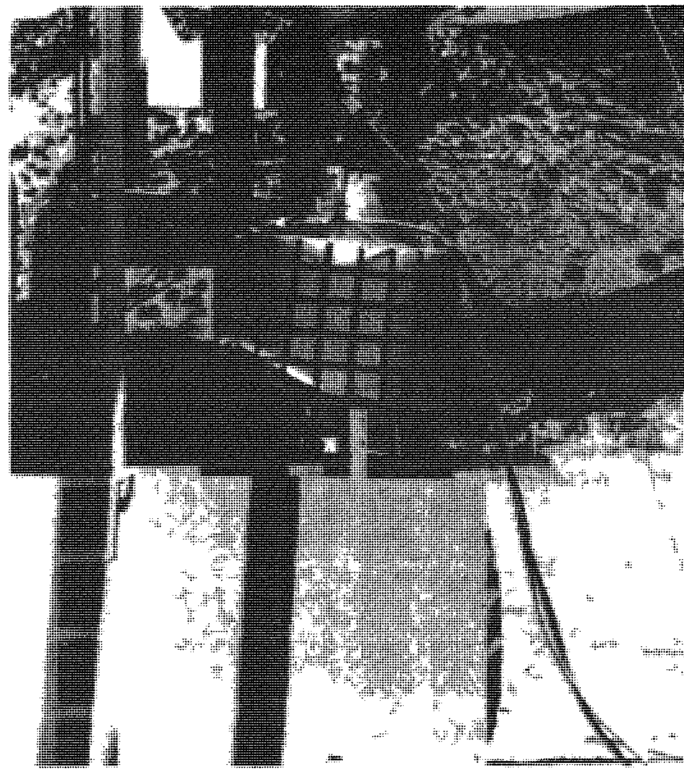
The results of the drop tests confirmed the predictions made in the structural analyses on the strength and behavior of the cask and canister structures during accident conditions. The drop tests provide conclusive evidence of the validity of the analytical models. The test results were given to the NRC to accelerate resolution of potential delays for questions about the amount of conservatism used in the structural analyses.

Cask Tests

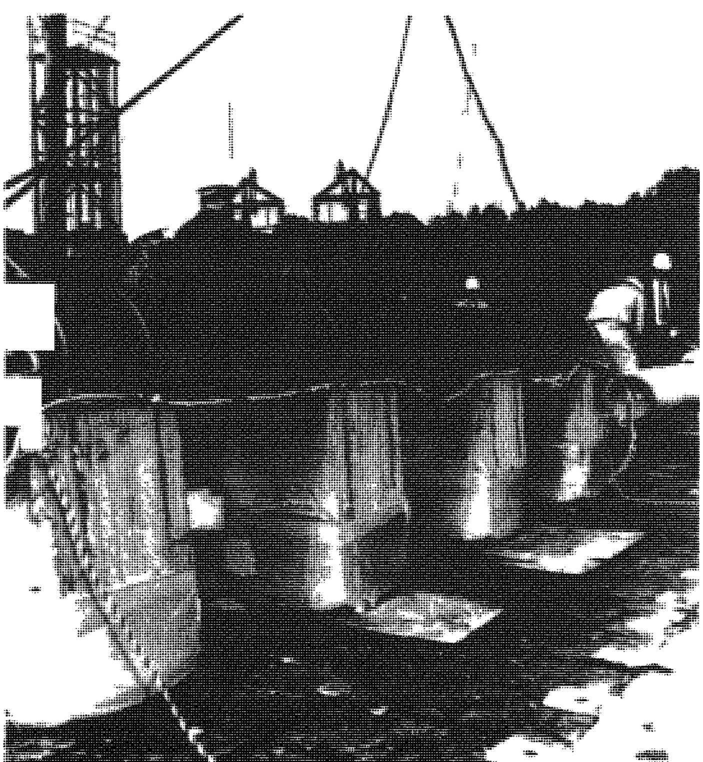
To ensure that only safe packages are used in transport, NRC regulations require that spent fuel shipping casks survive a series of severe accidents, including (in sequence) two drops of the package in an orientation to produce the maximum damage. The first drop is from 30 feet onto an



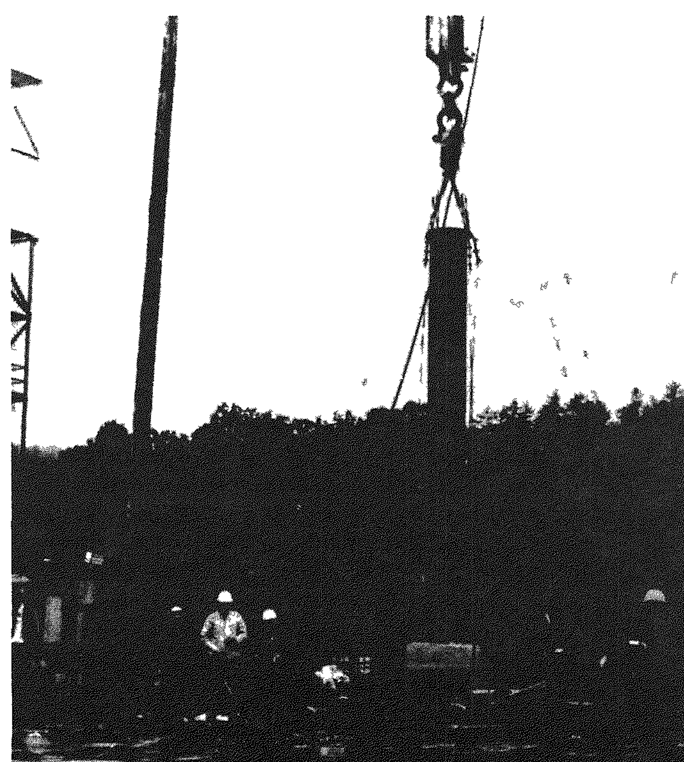
End puncture drop at the instant before impact.



Puncture drop height and orientation check.



Cask simulation vessel with simulation impact limiters for horizontal drops.



Cask simulation vessel and simulation impact limiter for vertical drops.

unyielding surface, followed by a drop from 40 inches onto a steel rod that is long enough to produce maximum damage to the package. The two drops are followed by a 30-minute fire at a temperature of 1475°F, after which the package is assumed to be flooded with water so that controls for subcriticality can be evaluated.

The damage from the 30-foot drop, for both cask and canisters, was first predicted analytically for every possible angle of impact and then demonstrated with a series of drop tests. For the cask drop test program performed at Sandia National Laboratories, a one-quarter-scale model was used. (Scale-model testing is an engineering practice that is used extensively in solving problems in aerospace, civil, mechanical, and nuclear engineering. The scaling laws are widely accepted and provide a cost-effective method of demonstrating design adequacy.) The scale-model tests confirmed the predicted behavior of the full-size cask.

Several drops were made with the quarter-scale model to show, for different cask orientations, the maximum damage to different parts of the cask. Three drops were from 30 feet onto an unyielding surface. Two of the three drops were conducted at a temperature of -20°F to simulate an accident at subfreezing temperatures that might cause brittle materials to fracture upon impact.

The first 30-foot drop was onto the bottom end of the cask to determine how well the cask walls, lids, and closure bolts performed. The test also demonstrated that the energy absorbers within the inner vessel adequately protected the canisters. The oblique angle drop from 30 feet was onto the lid, at an angle that would maximize the stress on the cask body. The side drop from 30 feet was done to produce maximum loads on the inner vessel.

The first 40-inch drop onto a puncture rod demonstrated the integrity of the cask side wall in an accident where the outer foam overpacks are not effective in absorbing energy and the cask wall must absorb the impact of a protruding object. The second 40-inch drop onto the lid showed how the cask lid would remain undamaged in a puncture accident without reduction of the impact energy by the overpacks.

After the drop tests, the cask was disassembled, inspected, and damage to the overpacks was documented. The model cask was measured, leaktested, and x-rayed to ensure that any structural damage would be found. As expected, the test data confirmed the damage predicted by the analysis for the drop conditions.

The tests showed conclusively the safety of the cask, even in accidents involving severe impacts. For comparison, the impact in a drop from 30 feet onto an unyielding surface is about the same as an impact at 90 miles per hour into two feet of reinforced concrete.

Canister Tests

A series of drop tests with the fuel canisters showed that the square shroud did not move when surrounded by the lightweight concrete in the canister. A full-size knockout canister was subjected to four 30-foot drop tests at Oak Ridge National Laboratory.

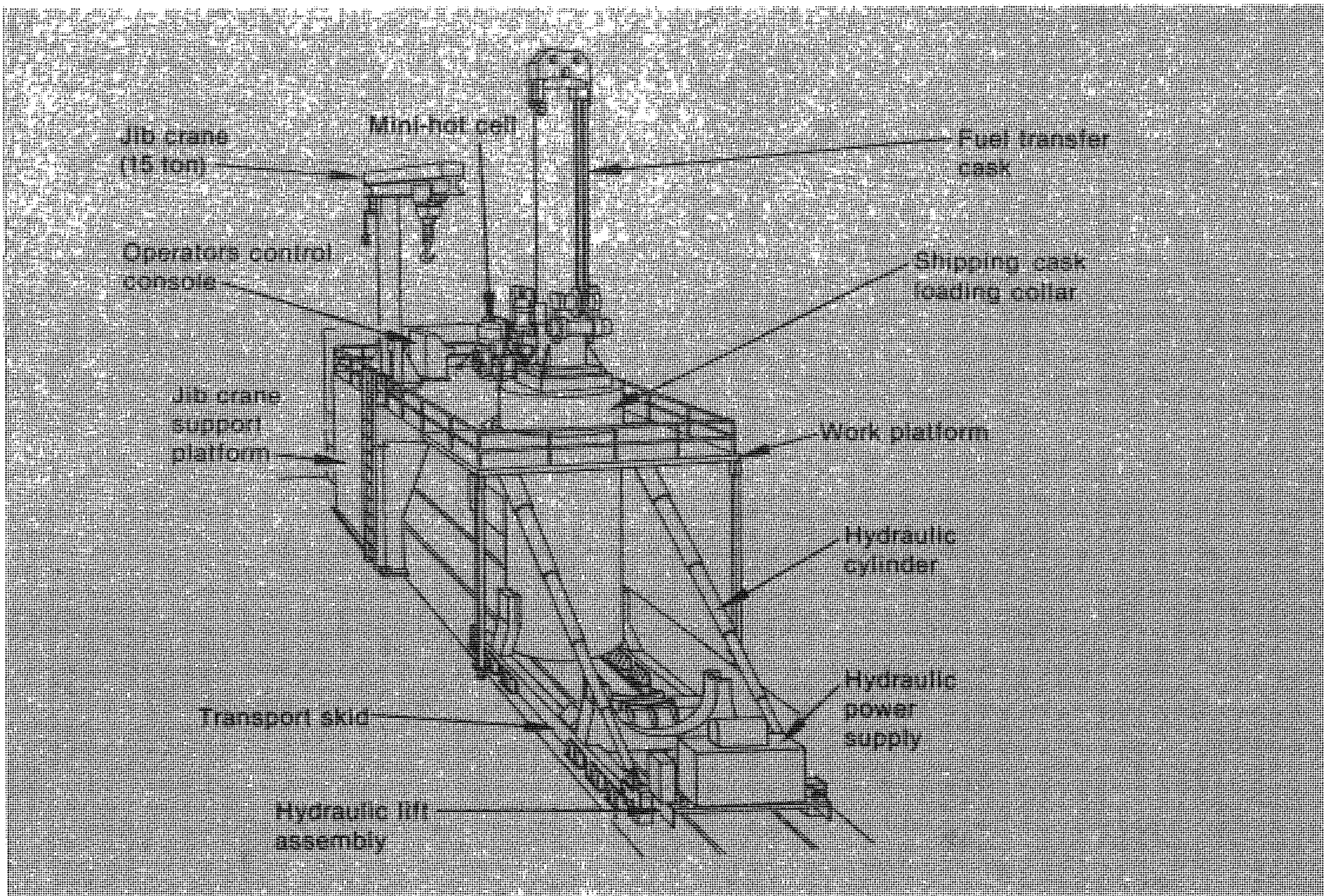
Two of the tests were with the canister in a vertical orientation. One drop test, onto the bottom of the canister, showed that the canister internal structures could safely withstand the force of the fuel debris coming down and compressing the tubes in the structure that contain the neutron absorbers. The second vertical drop was onto the upper end of the canister to show that the weight of the fuel debris could not apply forces that would pull the internal structure apart.

Two other drops were made with the canister horizontal to investigate bending and twisting of the internals. All four tests showed that the tubes containing neutron absorbers experienced no deformations beyond those determined by computer analyses of the structures.

Besides the drop test program, a thorough test program was performed on the catalyst beds installed in each canister to recombine the hydrogen and oxygen gases generated by radiolysis of water. In each test, the performance of the catalyst bed was measured while hydrogen and oxygen gases were added at a flowrate about three times what is expected to be generated in a TMI-2 debris canister.

The testing program helped determine the size and shape of the beds to be built into each canister. The effects of the environments to which the catalyst beds would be exposed, such as chemicals in the water in the TMI-2 reactor, were also investigated. The catalyst test program provided conclusive evidence of the satisfactory performance needed to ensure safe transport of the TMI-2 fuel debris. □

New Loading Procedure Developed for Debris Canisters



TMI fuel cask loading components.

Because the spent fuel storage pools at TMI-2 were being used for accident recovery operations, fuel debris canisters could not be loaded underwater into a shipping cask, which is a traditional industry practice. Instead, the NuPac 125B rail cask is loaded in the TMI-2 truck bay, with the canisters brought to the rail cask in lead-shielded transfer equipment.

The cask loading procedure begins after the overpacks are removed from the cask. The railcar and cask are positioned under a cask unloading station in the truck bay. Screw jacks on the cask unloading station are used to lift the cask and the transport skid from the railcar. The railcar is moved out of the truck bay, the cask and skid lowered to the floor, and the truck bay door closed. The cask unloading station is then moved and stored out of the way.

Two hydraulic cylinders are attached to the cask to raise it from a horizontal lay-down position to a vertical position. The cask is locked in place by attachment to a support tower. A work platform is bolted around the cask and connected to the tower. The cask is opened by removing the lids of the outer and inner containment vessels, and a shielded loading collar is installed. A mini-hot cell is moved over the cask and collar to remove and hold a shield plug from one of the seven tubes in the cask.

A canister is transferred from the spent fuel storage pool by the fuel transfer cask and lowered into the shipping cask. The canister transfer process is repeated six more times. Radiation exposure to workers is controlled by the lead shielding that is built into the mini-hot cell, fuel transfer cask, and loading collar.

After canister loading is finished and the mini-hot cell and loading collar are removed, both the inner and outer vessel lids of the cask are replaced and independently leak-tested to ensure that the cask is assembled correctly. The cask is then lowered to a horizontal position, placed on the railcar, reassembled with overpacks, and inspected and surveyed for radiation levels before being moved to the TMI north gate for transport by the railroad carrier.☐

Rail Transportation Program Developed for Cask

In conjunction with the development of the NuPac 125B rail cask and railcar, a transportation program was formulated to ensure the safety of the public while the cask and railcar are in transit to Idaho. The Union Pacific Railroad is the only railroad which serves INEL and was requested by EG&G Idaho to publish a rate for TMI-2 fuel debris traffic from TMI-2 to INEL. The Union Pacific Railroad in turn contacted Conrail, (the railroad that serves the TMI site) as well as other potential connecting carriers serving the northeast United States. EG&G Idaho and DOE are reviewing the potential routes to ensure that they are appropriate in terms of track safety and service requirements.

The railroads being considered are hazardous-material carriers that consistently earn railroad industry recognition for safety of operations and maintenance of track. Evaluation of the routes proposed by the railroads will include various factors such as the highest quality track available, which results in the shortest possible schedule using regularly scheduled railroad service. The routes ultimately selected will be through relatively low populated areas where possible. These requirements will result in a route with connections and tracks that have a low accident frequency index and a minimum number of switching stations.

The casks will ride on new railcars, each with 8 axles and a load capacity of 150 tons. A special design consideration for the rail cars was a safety margin such that the rated capacity of the railcar comfortably exceeded the loaded weight of the cask.

Railroad personnel will maintain continuous contact and use surveillance controls during transport. The railroads have the responsibility for handling any incidents that may occur during shipping and have established emergency procedures and trained personnel to handle hazardous shipments.

In the unlikely event of an accident during shipment, the railroad would take the initial action of isolating the train. Based on the severity of the accident, a nationwide emergency response system could be mobilized if necessary. Because of the safety designs built into the TMI fuel shipping casks, it is highly unlikely that, even in a rail accident, a breach of container integrity would occur.

Should an emergency occur, the DOE has established eight regional offices to provide radiological assistance. Any of these offices can mobilize an emergency response team within two hours; the team can arrive at an accident scene within eight hours. Nationwide, 28 DOE radiological assistance teams are available. The number of personnel responding and type of equipment assigned would depend on the nature of the emergency.

The total shipment time from TMI to Idaho is expected to be less than two weeks. With more than 250 canisters expected to be used and 7 canisters per cask, 35 to 40 shipments are planned. While one cask is being loaded at TMI, another will be being unloaded at the INEL.

Shipments are expected to begin in mid-1986 and should be completed in two to three years. Before actual shipments begin, the designated governor's representative in each state through which the shipments pass will have received a notice of the pending shipping campaign. DOE, which is responsible for shipping the TMI-2 fuel debris, will continuously monitor all aspects of the fuel shipping program. ☐

Core Debris to be Stored at INEL; Researchers to Have Access

On arrival at the INEL, the rail cask is removed from the railcar and transferred to a truck transporter for the 30-mile trip to the research and storage facility Hot Shop at Test Area North. Inside the Hot Shop, operations for unloading the canisters from the cask are done remotely.

Each canister is withdrawn from the cask, taken to a pool of water, and lowered into a storage module. Each module holds up to six canisters. When a storage module is full, each canister is vented with a specially designed venting and gas sampling system before being filled with demineralized water.

The modules are moved to storage locations in the pool and placed together, but not interconnected. After each module is in place, a gas venting line is connected to each canister. These fuel storage modules were designed to be stable and subcritical under all potential accident conditions.

Storage of the TMI-2 core debris is planned for up to 30 years at INEL, a DOE-owned facility located 50 miles west of Idaho Falls, Idaho. At the INEL, researchers will have access to core debris for the core examination research and development program. Until now, they have had only small samples of the damaged core to examine. While progress in understanding the accident sequence at TMI has been made, scientists at the INEL and at other nuclear research facilities can develop the fullest possible understanding only by studying debris from many core locations. This stored material will offer them that opportunity. ☐

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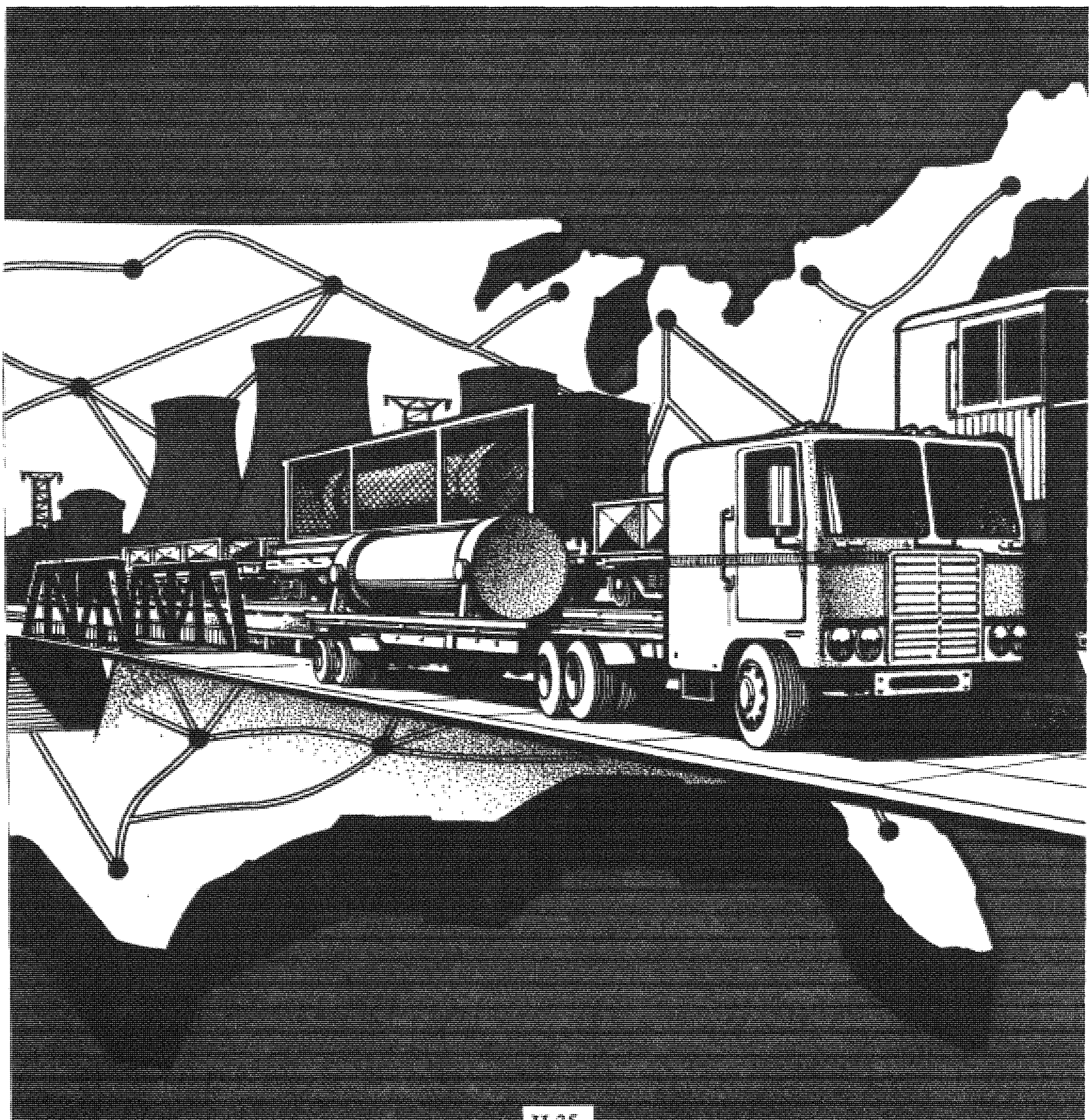
U.S. NUCLEAR REGULATORY COMMISSION

Transporting Spent Fuel

Protection Provided Against Severe Highway and Railroad Accidents



U.S. NUCLEAR
REGULATORY
COMMISSION

Transporting Spent Fuel

Protection Provided Against Severe Highway and Railroad Accidents

March 1987

Author: William R. Lahs

Division of Regulatory Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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INTRODUCTION

This report summarizes the results of a study conducted for the Nuclear Regulatory Commission (NRC) to determine the level of safety provided during shipments of spent fuel from U.S commercial nuclear power plants. The study focuses on the protection provided for shipments that may be involved in truck or railroad accidents.

During shipment, the cask and the form and structure of the spent fuel being shipped provide the primary physical means for containing radioactivity and for limiting radiation levels outside the cask. These functions must be maintained at acceptable levels even under the wide range of forces the cask and fuel could be subjected to during an accident.

Spent fuel shipments are regulated by both the Department of Transportation (DOT) and the NRC. The NRC evaluates and certifies the design of the shipping casks used to transport spent fuel, while DOT regulates vehicles and drivers.

Current NRC regulations require that shipping casks meet certain performance standards. The performance standards include normal operating conditions and hypothetical accident conditions a cask must be capable of withstanding without exceeding specified acceptance criteria that (1) limit releases of radioactive material and radiation levels outside the cask and (2) assure that the spent fuel will remain subcritical (that is will *not* undergo a self-sustaining nuclear reaction).

The study, conducted by Lawrence Livermore National Laboratory (LLNL),* began with an assessment of the possible mechanical and/or thermal forces generated by actual truck and railroad transportation accidents. The magnitudes of forces from actual accidents were compared with forces attributed to the "regulatory-defined" hypothetical accident conditions. The frequency of the accidents that can produce defined levels of thermal or mechanical forces was also developed. With this information, the study results show that for certain broad classes of accidents, spent fuel casks provide essentially complete protection against radiological hazards. For extremely severe accidents, those that could conceivably impose forces on the cask greater than those implied by the hypothetical accident conditions, the likelihood and magnitude of any radiological hazard were conservatively calculated. The study also contains an evaluation of the radiological risk from transportation accidents. Risk represents the summation of the products of the magnitude and likelihood of all accident outcomes. The purpose for making the risk calculations was to compare the resulting values with those previously used by NRC in judging the adequacy of its regulations.

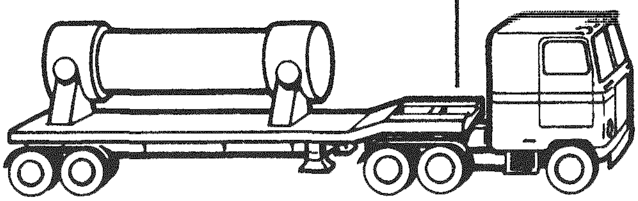
The purpose of this summary, prepared by the NRC staff, is to present the results of the LLNL study to a broad range of readers who may possess varying degrees of knowledge on the technical subjects covered in the LLNL technical report. As a result, this summary focuses on the overall approach and major results of the study. Although this summary describes many important assumptions and insights, a complete understanding of the scope and meaning of the LLNL work would require, as a minimum, frequent reference to the main LLNL report and its supporting appendices.

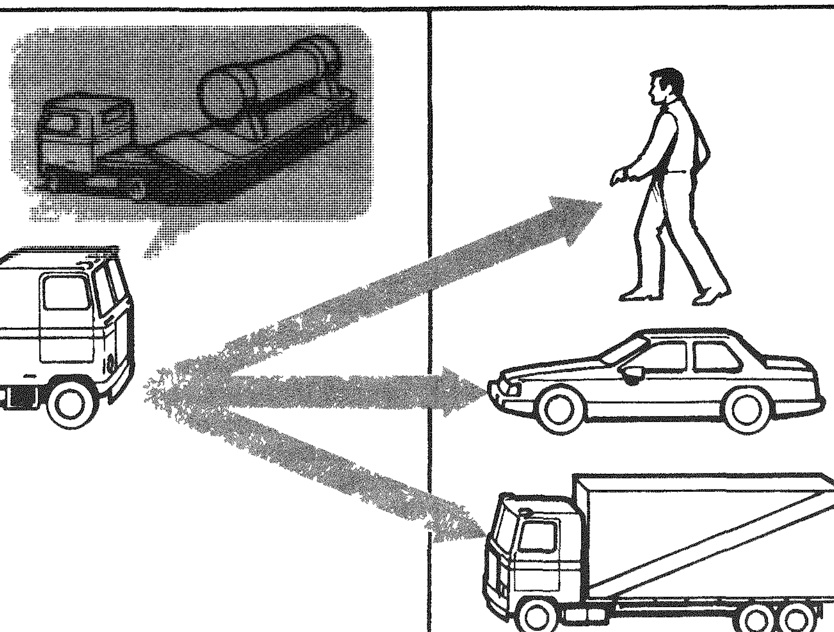
For the reader interested solely in the results of the LLNL study, the figure on the next page, the foldout on page 29, and the discussion under "Summary of Objective and Results" should be consulted. Readers wishing to understand the logic of the approach and the basis for major assumptions should refer to the main body of this summary report, which presents a step-by-step explanation of the separate tasks required to meet the study's objectives.

* "Shipping Container Response to Severe Highway and Railway Accidents," NUREG/CR-4829, February 1987. This report underwent peer review by the Denver Research Institute. The LLNL report and documentation resulting from peer review are available for inspection and copying at the NRC Public Document Room, 1717 H Street, NW, Washington, D.C. Formal NRC reports are available for purchase through the Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082, Washington, D.C. 20013-7082.

OVERVIEW

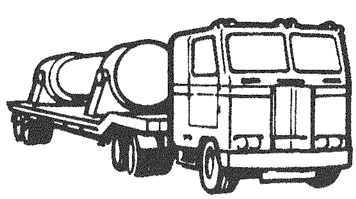
Accidents With No Expected Radiological Hazards





∼950 of Every 1000 Accidents

- "Soft" Target Vis-a-Vis Spent Fuel Cask
- No Fire or Fire of Either Limited Extent, Temperature, or Duration



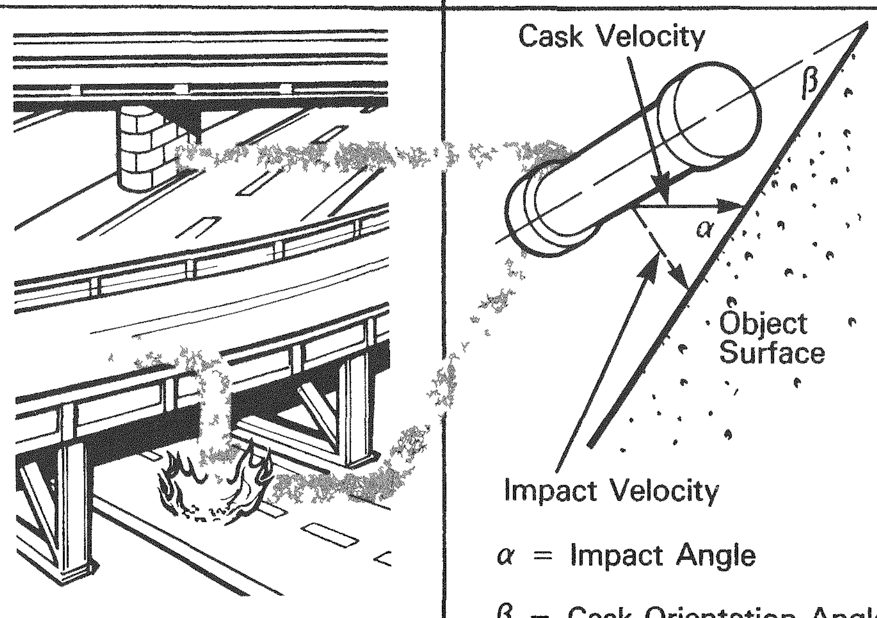
∼44 of Remaining 50 Accidents

One or More of the Following Apply:

- Velocity Too Low
- Impact Angle Too Shallow
- Object Surface Too Soft
- No Fire or Fire of Either Limited Extent, Temperature, or Duration

Conclusion:

994 of Every 1000 Truck Accidents Generate Forces Incapable of Causing Cask Functional Damage.



Summary of Objective and Results

The objective of this study was to characterize the level of safety for commercial spent nuclear fuel shipments should they become involved in severe transportation accidents. Researchers evaluated a broad spectrum of severe, historically documented, truck and rail accidents that caused death, injury, or significant property damage and assessed the minimal level of performance that should be achieved by NRC-licensed spent fuel shipping casks. The results, illustrated in the figure on the opposite page, indicate that no radiological hazard would be expected in at least 994 of every 1000 severe transportation accidents. In only about one accident every 40 million shipment miles (or once every 13 years assuming 3 million shipment miles per year) would minor functional cask damage be expected. If any radiological hazards were created, their magnitude would be expected to be less than currently-defined compliance values in existing regulation. In only about one accident every 80 million shipment miles could cask damage be significant enough to cause a radiological hazard which could equal or slightly exceed existing compliance values.

The data from documented severe accidents had to be extrapolated to characterize extremely severe accidents for which experience provided no models. This process led to the finding that in about 1 in 100,000 truck accidents and 1 in 10,000 rail accidents, extensive damage to cask and fuel could occur. In these situations, engineering judgment was used to conservatively estimate the resulting radiological hazard; however, predictions made under such unlikely accident conditions are subject to uncertainty.

In an attempt to gauge this uncertainty, the study assessed the potential for a radiological hazard in extremely severe accidents by assuming that a spent fuel shipping cask with minimally acceptable capabilities was involved in the four documented severe accidents shown on page 29. The most likely outcome in three of these four accidents would be minor or superficial damage to the cask and no radiological hazard. In the fourth, and under some circumstances in two of the three previous accidents, a radiological hazard could occur. Its magnitude would be less than or comparable to the hazard implied by compliance values in existing NRC regulations.

As a final point of reference, the risk of spent fuel shipments was evaluated and compared with previous estimates used in assessing the adequacy of existing regulations. The resulting risk level was less than one-third of past estimates.

BACKGROUND

Over the last 10 years, thousands of shipments of commercially generated spent nuclear fuel have been made throughout the United States without causing any adverse radiological consequence to members of the public. In the near future, the number of these shipments is expected to increase. More than 40,000 spent fuel assemblies have been used at nuclear power plants in the United States and are currently being stored in underwater "fuel pools" at these sites. Under the terms of the Nuclear Waste Policy Act (NWPA) of 1982, these spent fuel assemblies will be placed in a Federal Repository for permanent storage beginning in 1998. Shipments from reactor sites to the Repository for ultimate disposition will require increased rail and road movement of spent fuel.

In part, because of the projected increase in the number of spent fuel shipments, the U.S. Nuclear Regulatory Commission (NRC) decided to reassess the level of safety provided by casks designed to existing regulations.

In large measure, the safety associated with spent fuel shipments, especially in the event of a transportation accident, is provided by the casks that contain the spent fuel during shipment. These casks must meet performance requirements specified in the *Code of Federal Regulations* (10 CFR 71) and their design must be certified by the U.S. Nuclear Regulatory Commission.

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Other elements of safety are provided by the Department of Transportation's operating requirements for vehicles and drivers. These operating requirements are defined under Title 49 of the *Code of Federal Regulations*.

What Is Spent Nuclear Fuel?

Spent nuclear fuel refers to uranium-bearing fuel elements that have been used at commercial nuclear power reactors. This spent (used) fuel contains radioactive material resulting from the fission process that takes place within the reactor. The radioactive material is formed within ceramic fuel pellets about the diameter of an aspirin tablet but twice as thick. These pellets are contained in 15-foot-long sealed metal tubes or rods—a few hundred per rod. From about 50 to 400 of these rods are grouped in a square array to form a spent fuel assembly.

When spent fuel is removed from the reactor, the self-sustaining fission process has stopped; however, spent fuel assemblies still generate significant amounts of radiation and heat. This heat and radiation are caused by the "radioactive decay" of the products of the fission process. The actual material emitting the radiation is, for the most part, still contained within the ceramic fuel pellet. Some material, however, mainly in gaseous or volatile form, can leave the pellet. This material is normally contained within the metal fuel rods that surround the pellets.

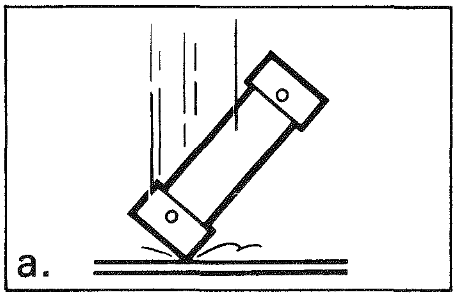
The heat and radioactivity in spent fuel necessitates that any shipment be made in containers or casks that provide the necessary degree of public protection. In practice, this means a cask must shield and contain the radioactivity and dissipate the generated heat.

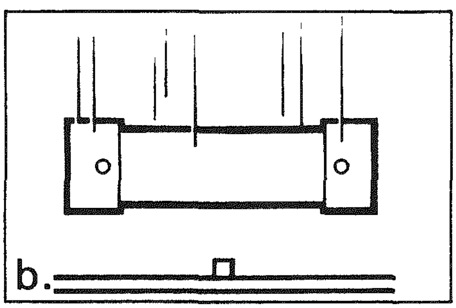
How Is Safety Achieved?

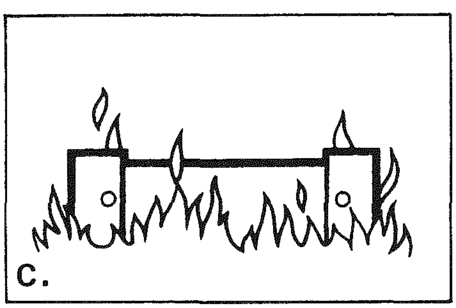
Safety in the shipment of spent nuclear fuel is achieved by a combination of factors including the physical properties of the spent fuel itself, the ruggedness of the container or cask containing the fuel, and the operating procedures and controls applicable to both the cask and the vehicle transporting the cask. If a transportation accident should occur, safety is primarily assured by the integrity of the spent fuel shipping cask. The design of all casks used to ship commercially generated fuel in the United States must meet performance-oriented requirements specified in Federal and international regulations. The performance requirements include the definition of a series of "hypothetical accident conditions," described on the opposite page. All licensed casks must be capable of withstanding the mechanical and thermal loadings imposed by these conditions and still meet specified acceptance criteria.

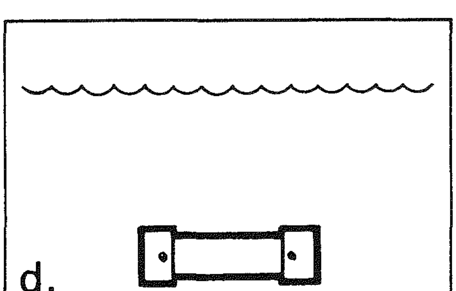
These acceptance criteria include: (1) stringent limits on both the maximum allowable release of radioactive material and the radiation levels outside of a cask and (2) requirements regarding cask configurations which assure that subcriticality of the spent fuel is maintained.

In practice, NRC verifies conformance with these acceptance criteria by analyses demonstrating that essentially no permanent deformations or excessive temperatures occur within a cask's containment shell following the sequentially applied loadings imposed by hypothetical accident conditions. Demonstrations that casks can withstand these conditions, coupled with information about cask designs and construction materials, suggests that casks should be capable of withstanding far greater mechanical and thermal loadings during an accident than those caused by hypothetical accident conditions without causing any significant radiological hazard. The LLNL quantifies this capability through two supporting analytical assessments. The first identifies actual documented accidents in which mechanical and thermal loads would be less than those implied by the hypothetical accident conditions. The second identifies accidents (and their likelihood of occurrence) in which loads could exceed those specified in the regulations and evaluates the capability of a cask to continue to function safely under such conditions.









Standards for Spent Fuel Casks

For certification by the NRC, a cask must be shown by test or analysis to withstand a series of accident conditions. These conditions have been internationally accepted as simulating damage to spent fuel casks that could occur in most severe credible accidents. The impact, fire, and water-immersion tests are considered in sequence to determine their cumulative effects on one package. A separate cask is subjected to a deep water-immersion test. The details of the tests are as follows:

Impact

Free Drop (a) — The cask drops 30 feet onto a flat, horizontal, unyielding surface so that it strikes at its weakest point.

Puncture (b) — The cask drops 40 inches onto a 6-inch-diameter steel bar at least 8 inches long; the bar strikes the cask at its most vulnerable spot.

Fire (c)

After the impact tests, the cask is totally engulfed in a 1475°F thermal environment for 30 minutes.

Water Immersion (d)

The cask is completely submerged under at least 3 feet of water for 8 hours. A separate cask is completely immersed under 50 feet of water for 8 hours.

Insights on the Safety Provided by Typical Spent Fuel Shipping Casks

Over the last decade, considerable experimental and analytical evidence has been gathered to provide insights into the safety provided by spent fuel shipping casks. The most dramatic evidence has involved full-scale crash tests carried out both in this country and in Great Britain. Trucks and rail cars carrying casks have been run head-on into massive concrete barriers at speeds from 60 to over 80 mph. Casks have also been struck by locomotives travelling at 100 mph and have been immersed in fires in which temperatures have been deliberately kept high. In all tests, the resulting cask damage ranged from superficial to very minor. These results certainly attest to the overall ruggedness of the casks tested and the general integrity of their design. From an analytical standpoint, the most notable effort to provide insights into the safety of spent fuel shipments involved the preparation of a generic environmental statement on the shipment of all radioactive materials, including spent fuel.* This study included an evaluation of the risks from transportation accidents involving shipments of radioactive material. Risk is a measure that multiplies all potential radiological hazards by

* "Transportation of Radioactive Material By Air and Other Modes," NUREG-0170, December 1977.

OVERVIEW

their individual likelihood of occurrence and sums the results. The risk associated with all radioactive material shipments was so small that the Nuclear Regulatory Commission judged that its regulations regarding the packaging of these materials were adequate and not in need of immediate change. The Commission did call for continuing efforts to further understand the hazards and risks posed by the transportation of radioactive material. The LLNL study is one result of that effort.

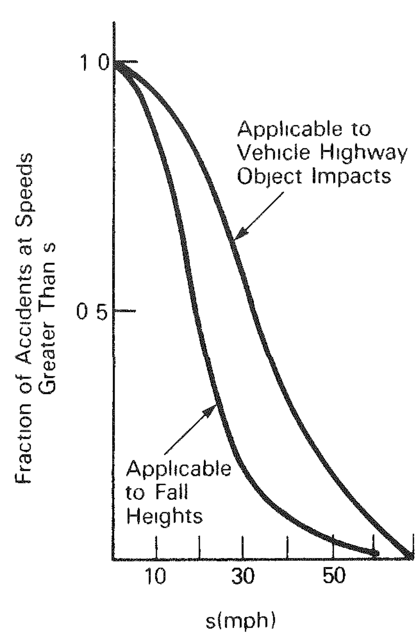
Accident Scenarios

Spent fuel shipments could be subjected to a variety of transportation accident situations or scenarios. Identifying these potential scenarios began with the historical data from typical truck accidents that involved deaths and injuries or those that exceeded certain levels of property damage. Data from minor accidents (e.g., fender benders) were excluded.

Highway

Most of the information on the likelihood of single and multi-vehicle accidents in the figure on the opposite page is based on historical data. The solid lines show accident scenarios derived from the historical data whereas the dashed extrapolations consider the potential effects of cask impacts with a variety of hard objects or surfaces. Impacts with these types of objects or surfaces have the greatest potential for causing damage. The extrapolation was made by merging documented accident data with statistical data representing highway terrain and adjacent structures. This data was obtained from recorded information and by surveying hundreds of miles of typical interstate highway to determine how frequently surfaces and objects such as large bridge columns or hard rock surfaces occur. Most spent fuel shipments will be made over such interstates.

TRUCK ACCIDENT SPEEDS



The historical data also provided the basis for developing speed distributions typical of the accidents (see the figure on this page).

The speed distributions were based on (1) estimated vehicle speeds at time of impact; (2) speeds attained in falls (where fall heights were calculated from a survey of bridge heights along interstate highways); or (3) combinations of these speeds. For the truck-train scenario, the train speed distribution reflects the historical data applicable to grade-crossing accidents.

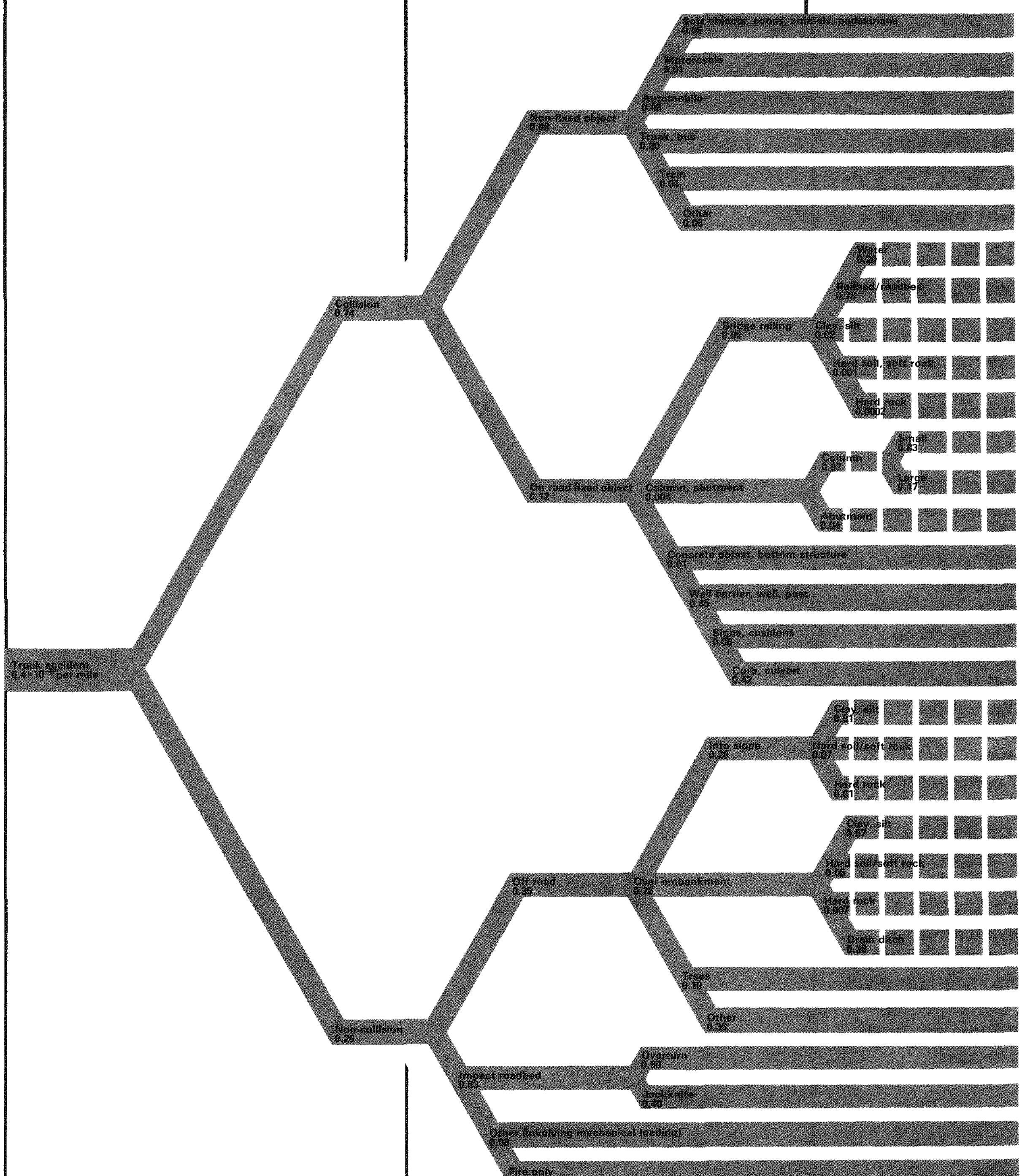
Historical data on accident-related fires was limited to statements of whether or not a fire occurred. Information on the duration and temperatures of fires, and of their location with respect to a vehicle's cargo was extremely sparse. As a result, the environments typical of accident-related fires had to be assessed through an engineering model. This model is discussed in the following section on railroad accident scenarios.

Occurrence Rates for Truck Accident Scenarios

† Rounded values

* Accident sequences subsequently shown to have the most likely possibility of causing cask damage

■■ Developed extensions of historical scenario data



OCCURRENCES PER 1000 ACCIDENTS†	INDEX
34	1
8	2
432	3
133	4
8	5*
38	6
1	7*
4	8*
0.08	9*
0.006	10*
0.001	11*
0.3	12*
0.06	13*
0.01	14*
0.9	15
40	16
5	17
37	18
23	19*
2	20*
0.3	21*
13	22*
1	23*
0.2	24*
9	25
9	26
33	27
83	28
55	29
20	30
10	31

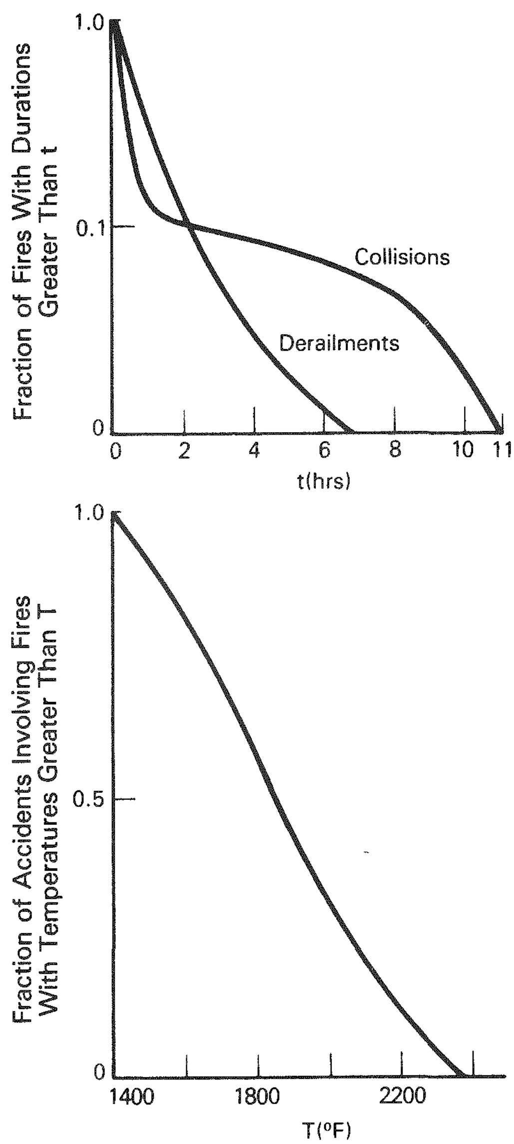
Railroad

Railroad accident scenarios were also based on documented rail accidents involving deaths, injuries, or property damage exceeding small thresholds. This historical data provided the bases for the likelihood of accident scenarios shown in the figure on the opposite page. The dashed lines indicate accident scenarios derived mainly from route survey information. They were developed to more accurately determine the types of accidents with the potential to cause functional damage to the cask.

The available historical fire-accident data, pertinent to both rail and truck accidents, could not be used to determine potential thermal loadings on casks. Therefore, an existing computer code, previously developed to characterize transportation accident fires, was used to estimate the likelihood of fire temperatures and durations. The code evaluated data on accident type, cause of fire, availability of combustibles, fire-fighting efforts, and combustible burning rates to predict the likelihood that fire temperatures and durations would reach specific values. The top graph on this page shows this evaluation for railroad collision and derailment accidents. The bottom graph gives the results of the evaluation applicable to temperatures for both truck and rail accidents.

These results, which included several conservative assumptions, were used to represent transportation accident fires. For example, for railroad accidents involving collisions, about 10% of all fires were estimated to last longer than 2 hours. Temperatures in over half of such accidents were estimated to exceed 1800°F.

FIRE DURATIONS AND TEMPERATURES

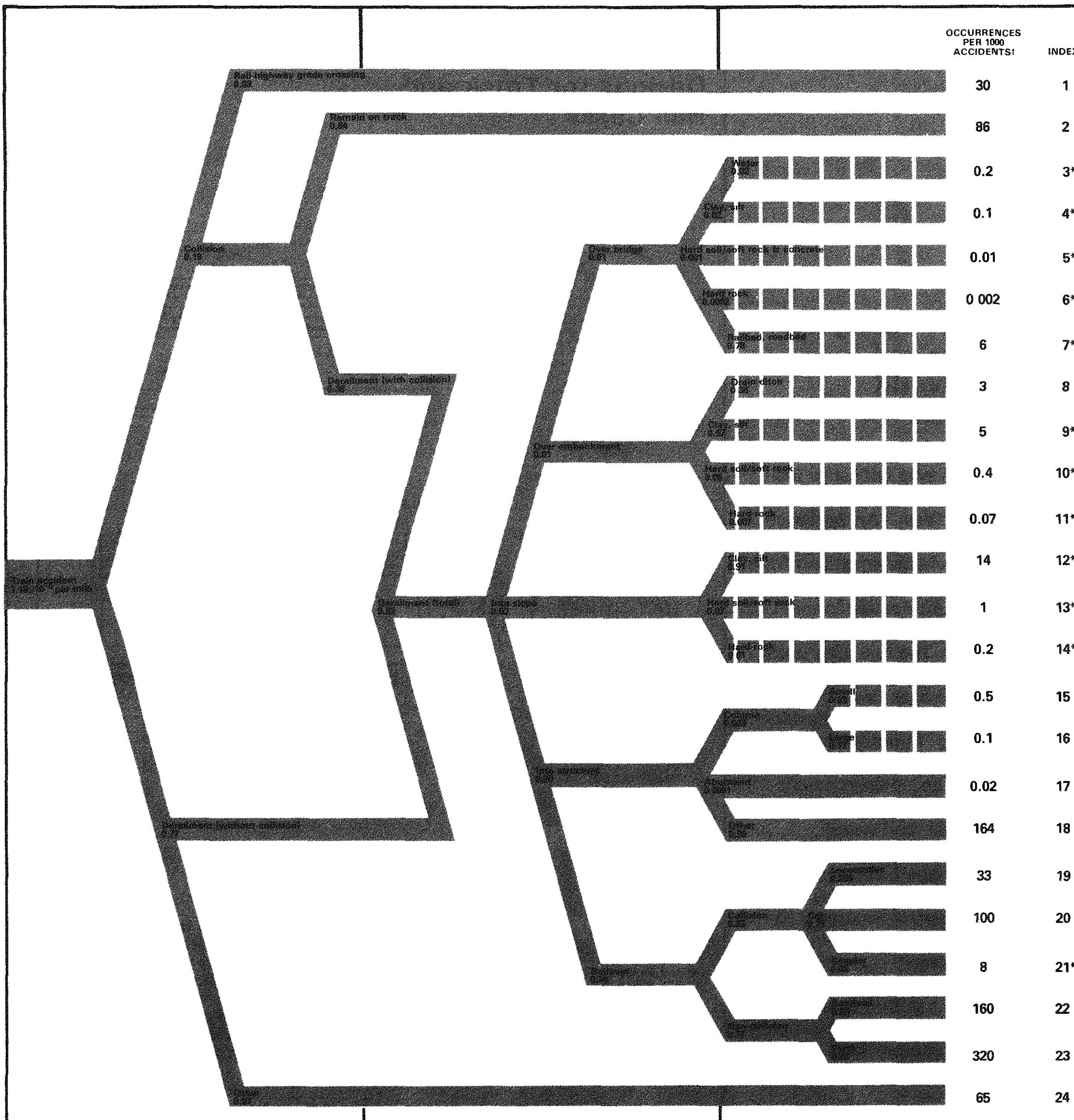


Occurrence Rates for Railroad Accident Scenarios

† Rounded values

* Accident sequences subsequently shown to have the most likely possibility of causing cask damage

■■ Developed extensions of historical scenario data

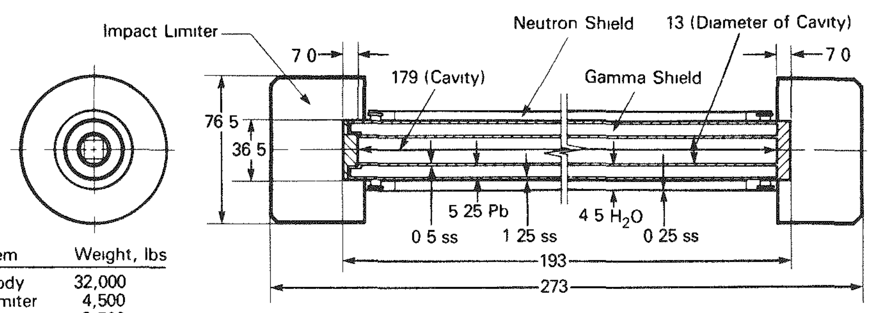


CASK CHARACTERISTICS AND RESPONSES

Can Cask Safety Be Characterized in Real-World Accidents?

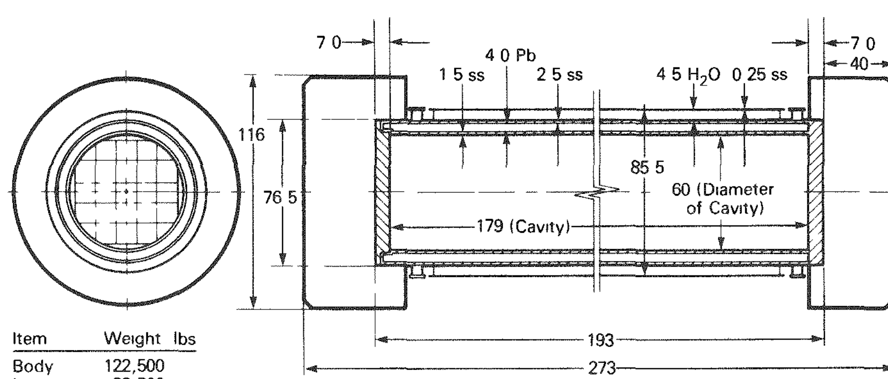
This question was critical to the credibility of the LLNL study. The answer was "Yes." An approach to the problem could be followed to allow fair characterization of the minimal level of safety that would be meaningful to an assessment of the adequacy of existing regulatory requirements. The first step taken in this approach was to define two representative cask designs—one for truck shipments and one for rail shipments. In both cases, the casks were designed to just meet "regulatory" acceptance criteria following an accident with mechanical, thermal, and water-immersion accident conditions depicted on page 5. The cask designs included only those features absolutely necessary to determine a cask's ability to achieve its primary safety functions. (These safety functions and the cask features that achieve these functions are discussed briefly on pages 11 through 13.)

Representative Designs for Truck and Rail Casks



Item	Weight, lbs
Body	32,000
Limiter	4,500
Contents	2,500
	39,000

TRUCK CASK



Item	Weight lbs
Body	122,500
Limiter	22,500
Contents	52,500
	197 000

RAIL CASK

All Dimensions in Inches

ss = Stainless Steel
Pb = Lead
H_2O = Water

Note:
The representative truck and rail casks consist of stainless steel cylindrical shells that enclose a ring of lead shielding material. A water jacket surrounds this cylindrical structure. At each end of the cask, an "impact limiter" is provided to protect the cask against impact forces.

CASK CHARACTERISTICS AND RESPONSES

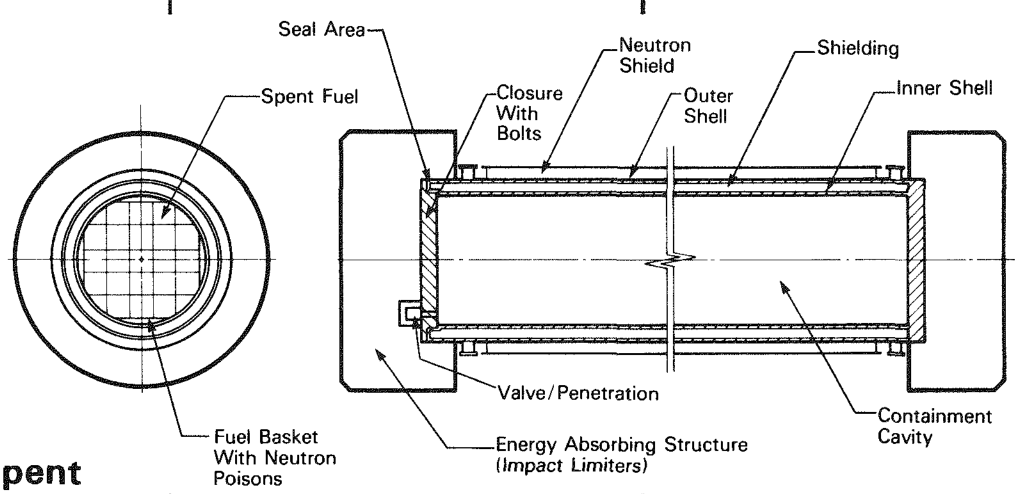
Once these representative cask designs were defined, they were subjected to the most damaging accident scenarios identified on pages 6 through 9 to determine their structural response. By measuring structural response, researchers estimated their potential for a radiological hazard. If the potential existed, the magnitude of the radiological hazard was conservatively evaluated. Through this process, that fraction of severe rail and truck accidents capable of causing a specified radiological hazard was estimated. The radiological hazard was then compared with compliance criteria in existing NRC regulations.

As an additional point of reference, the radiological risk of shipping commercial spent fuel was compared to documented estimates used by the NRC in making its past judgment on the adequacy of existing regulations (see insert on page 5).

Cask Safety Functions and Representative Cask Design Features

The primary cask safety functions include: (1) containment of radioactive material, (2) shielding against the radiation emanating from the spent fuel, and (3) assurance that subcriticality of the fuel is maintained.

Containment is achieved by retaining the radioactive material within a closed vessel. Typically, containment is provided by the integrity of the spent fuel cladding and by the cylindrical steel containment vessel or inner cask shell (see figure below). The vessel is provided with a bolted-end closure to permit loading and unloading. The closure contains a seal between the cask cavity and the environment that prevents leakage. Piping penetrations, which terminate in protected enclosures, are also provided for operational purposes. The required containment safety function is achieved by these features. Furthermore, the successful functioning of these features is promoted by (1) an externally located, energy-absorbing structure designed to protect the cask against impacts, and (2) the integration of the containment features into an overall cask design that maximizes protection provided against outside forces. In defining a representative cask, the complexities associated with various designs for containment closures, penetrations, and seals were not modeled. The failure of these features was assumed if the containment or inner shell was calculated to incur any significant *permanent structural damage.*

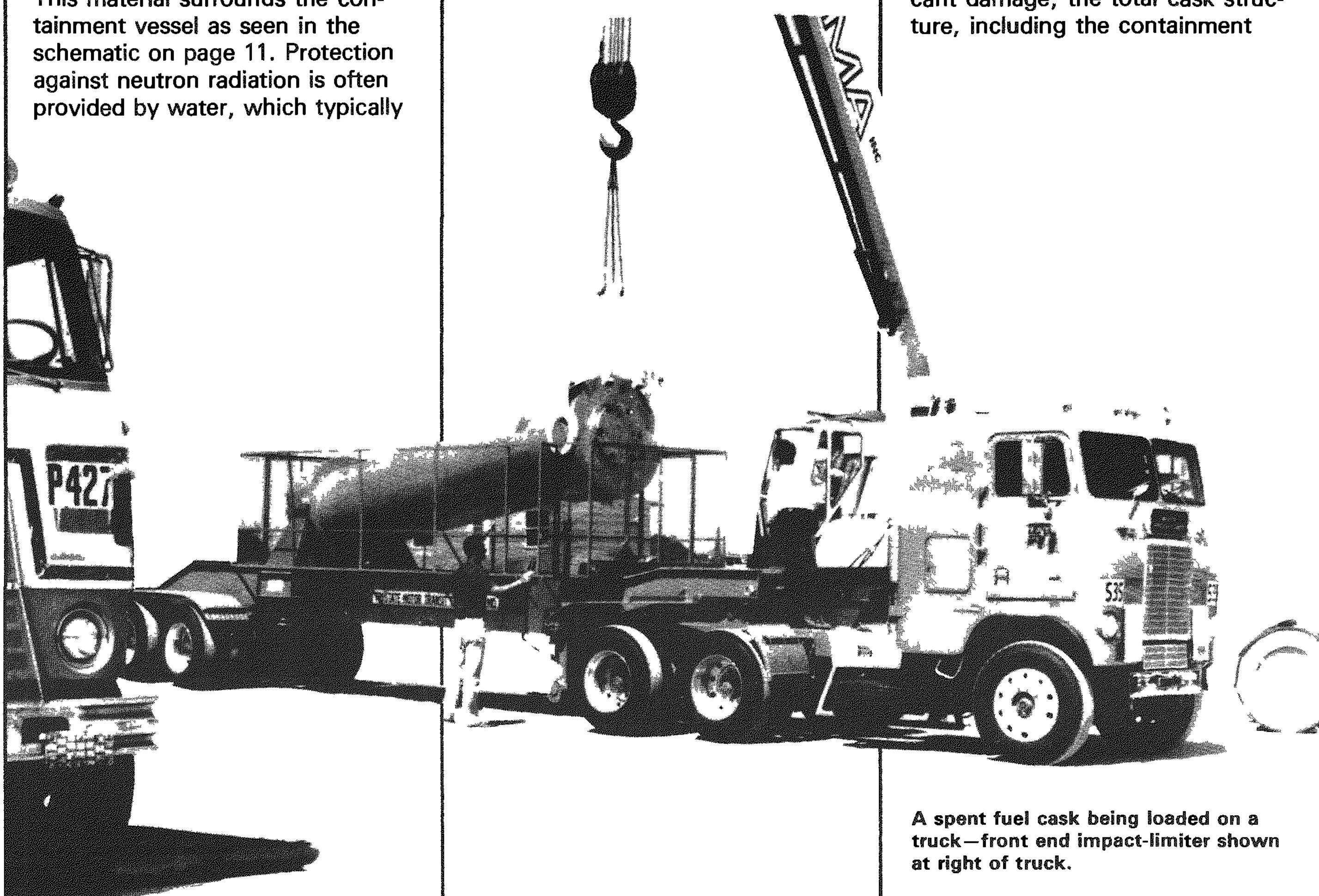


Schematic of Spent Fuel Cask

CASK CHARACTERISTICS AND RESPONSES

Shielding is provided against **gamma** and **neutron** radiation. Protection against gamma radiation which is very penetrating is most important and is achieved through use of heavy materials such as lead, uranium, or steel that reduce the radiation level. This material surrounds the containment vessel as seen in the schematic on page 11. Protection against neutron radiation is often provided by water, which typically fills a jacket surrounding the main cask body. Loss of the neutron shield normally results in a small increase in external radiation levels, but to a value that is within regulatory limits for transportation accidents. Failure of the neutron shield was assumed to occur for all accidents considered in this study. As a result, only the lead gamma shield was modeled in some detail in the representative cask designs.

Subcriticality is assured by either limiting the amount of spent fuel being shipped or by maintaining control of the spent fuel configuration during shipment and including "neutron poisons" in cask structural materials. The "poisons" are typically included in the solid structure or "basket" holding the fuel assemblies and absorb emitted neutrons, thereby making a "chain reaction" impossible and thus assuring subcriticality. Before the fuel basket can incur any significant damage, the total cask structure, including the containment



A spent fuel cask being loaded on a truck—front end impact-limiter shown at right of truck.

Note.
Actual spent fuel casks like the one shown in this figure are expected to perform their intended safety functions during an accident better than the representative cask designs assessed in this study.

shell, would have to be severely damaged. However, physical damage alone does not affect a cask's ability to maintain subcritical conditions. A material like water must surround the cask and fill the area between individual fuel rods and fuel assemblies before criticality would be possible. For these reasons, the features to assure subcriticality are not specifically modeled in the representative cask designs. Instead, an upper-bound estimate of the likelihood of criticality is provided in the LLNL report. The estimate is based on the type of accident that could substantially deform a cask in the presence of a material, like water, that would promote criticality. A brief discussion of this estimate is presented in the section on potential hazards and risks on page 26.

What Constitutes a Severe Transportation Accident?

In this study, a severe accident is one that could compromise one of three basic cask safety functions: (1) any loss of containment of spent fuel material, (2) a degradation or reduction in cask shielding capability, or (3) a loss of subcriticality control. Any of these occurrences could potentially create a radiological hazard.

Severe accidents typically involve impacts with massive and hard objects or surfaces or exposure to high-temperature fires of long duration. The scenarios shown on pages 7 and 9 are those that could compromise a cask's safety functions and potentially cause a radiological hazard.

Given the ruggedness and massiveness of spent fuel casks, a severe accident in this study would *not* include tragedies involving collisions between the vehicle transporting the cask and an automobile or bus in which several people might be killed or injured. Although potentially serious to the occupants of such vehicles, collisions with automobiles and buses at any speed involve forces that would not seriously compromise cask safety functions. Any deaths or injuries from such accidents would not be caused by the radioactivity of the spent fuel cargo.

Establishing a Scale to Measure Cask Response

Mechanical Loads—Measure of Cask Response

A cask and the nuclear fuel it contains can undergo various types of damage when subjected to mechanical loads. The most significant damage would include material yielding, dimensional changes, and rupture of the cask. The most common engineering guidelines used to characterize structural damage are stress, strain and displacement. Strain, particularly on the inner "containment" shell of the cask, was selected as the best single indicator to characterize cask damage following a transportation accident. Sensitivity studies established a relationship between the strains at different cask locations and the maximum strains experienced in the cask containment shell. As a result, it was possible to use a specific strain in the cask shell to estimate damage to cask components such as seals, closures, and penetrations.

Three discrete levels of strain were defined to encompass four broad ranges of cask and fuel damage, as shown in the figure on the following page. The significance of the 0.2-, 2-, and 30-percent strain values, in terms generally indicative of cask and fuel damage, is also illustrated on page 14.

CASK CHARACTERISTICS AND RESPONSES

Thermal Loads—Measure of Cask Response

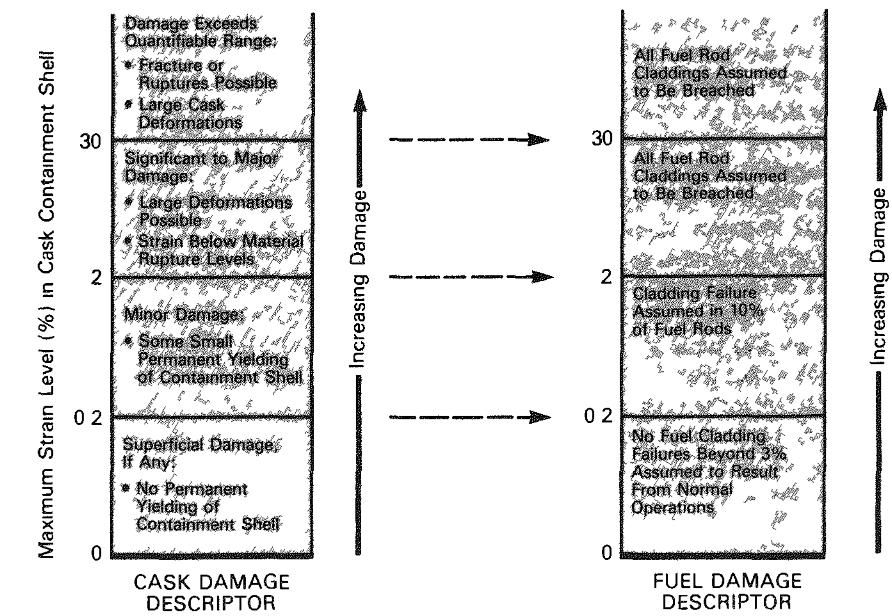
Heat from a fire can conceivably damage cask components, the cask structure itself, or the spent fuel. The more important types of damage can involve degradation of cask seals, melting of the lead gamma shield, or structural failures. The significance of high temperatures on spent fuel is that it can eventually cause the fuel rods to rupture and release radioactive material into the cask

The temperature at the centerline of the cask's gamma radiation shield is the indicator most likely to reveal the extent of cask damage from fires associated with transportation accidents. Four temperature levels are defined to categorize five ranges of cask and fuel damage These response ranges are indicated in the next column at the bottom of the page

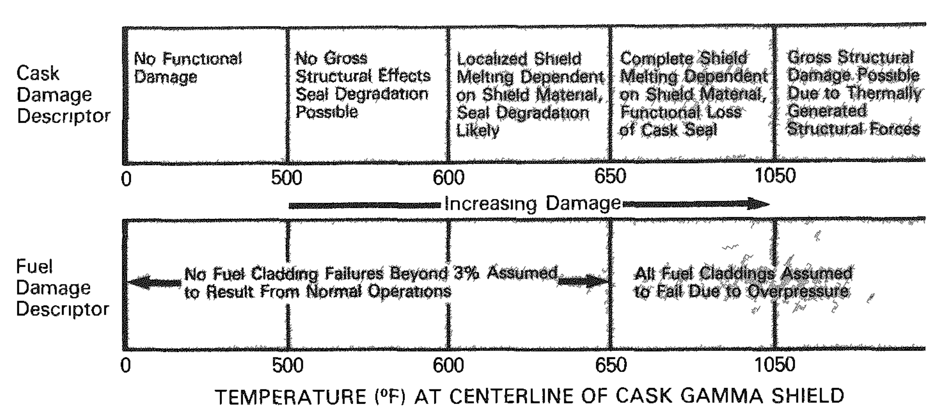
What Does Strain Measure?

When subjected to a force, the steel used in the cask containment shell can change dimension. The change in dimension of any segment of the steel shell along a given direction, when divided by the original length of the segment in that direction, is termed "strain." Strains experienced by materials under design loads are typically small, except for a few

Measures of Cask and Spent Fuel Response to Mechanical Loads



Measures of Cask and Spent Fuel Response to Thermal Loads



materials such as rubber. For a given material, the measure of strain can indicate whether a material will remain elastic and not deform or permanently yield or fracture and result in a rupture.

What Does Temperature Measure?

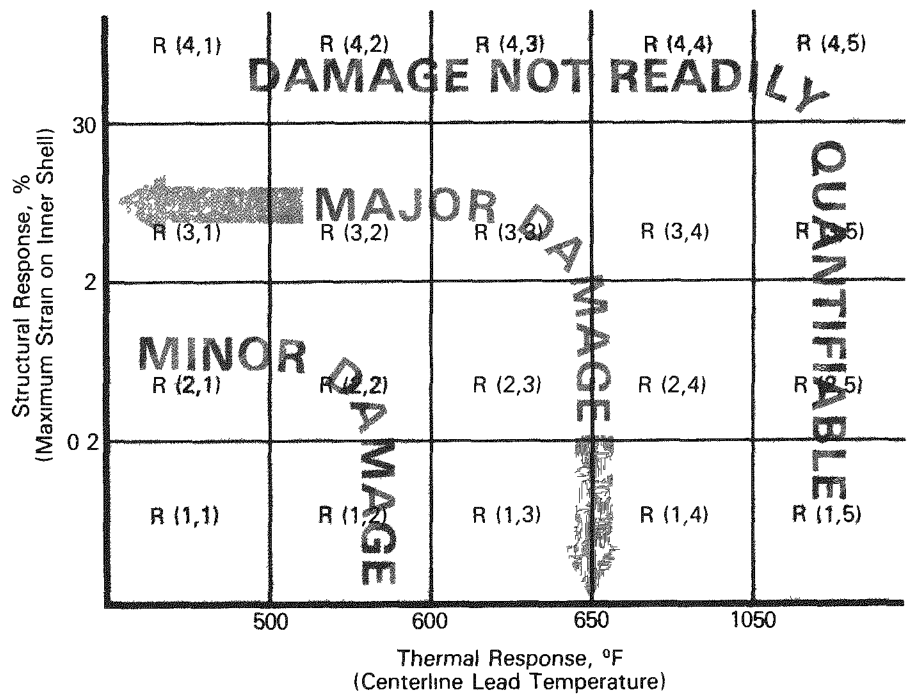
The temperature at points within a massive spent fuel cask can indicate the amount of heat absorbed from external sources such as fires and can also indicate potential cask or fuel damage. The cask can be damaged by the degradation of seals or the melting of the gamma radiation shield. For the spent fuel, the pressure of gases within the fuel rods, and the strength of the fuel cladding is strongly influenced by temperature. If temperatures become high enough, fuel rods could rupture and release radioactive material inside the cask.

Evaluating Cask and Spent Fuel Response to Accident Loads

On the previous two pages, cask containment strains and centerline shield temperatures were defined separately to characterize broad categories of cask and fuel damage. In real transportation accidents, however, a cask could undergo a combination of mechanical and thermal loads. The "cask response matrix" shown on this page therefore combines the

Cask Response (Damage) Regions

Note:
The size of each region or group of regions has no relationship to the likelihood of accidents causing the described damage level.



SUPERFICIAL DAMAGE—No permanent deformation to containment vessel. Temperatures too low to degrade material. Strains and temperatures less than or equal to *values considered acceptable following* imposition of "regulation-defined" hypothetical accident conditions.

MAJOR DAMAGE—Large containment vessel deformations without gross fractures or ruptures. Temperatures high enough to melt lead shielding.

MINOR DAMAGE—Limited permanent containment vessel deformations. Temperatures approaching the range where the lead shield could melt and the seals could degrade.

DAMAGE EXCEEDING DEFINABLE RANGES—Fractures or ruptures possible. Temperatures sufficiently high to affect cask and spent fuel integrity.

structural and thermal responses to categorize cask damage from all possible combinations of mechanical and thermal loads.

The process of categorizing cask response for a specific accident scenario is best described by an example. From the figure on page 7, scenario 20 indicates that about 2 of every 1000 truck accidents are expected to result in an impact into a slope consisting of hard soil or soft rock. Cask damage from this type of accident can be estimated (in terms of maximum containment vessel strain) if truck velocity, angle of impact, and cask orientation at impact are specified. Similarly, if a fire occurs during this accident (an event expected in about 1 of every 100 slope-impact accidents), damage to the cask can be estimated in terms of temperature at the centerline of the lead shield if the fire temperature, duration, and cask location relative to the fire are specified. The overall cask damage for the entire spectrum of transportation accidents characterized by cask impact with a soft rock slope can be calculated and placed into one of the response regions shown on page 15.

Two further steps are then required to complete the evaluation of the level of safety provided for spent fuel shipments. First, each response region must be considered in terms of the radiological hazard that could result from the specified level of cask damage. This relationship is described on pages 16 through 19. Second, the likelihood that the specific accident scenario (for example, impact into soft rock slope) can lead to a cask response within a particular region must be evaulated. This part of the evaluative process is further described on pages 20 through 27.

Relationship Between Cask Response and Potential Radiological Hazards

For most cask responses to transportation accident loads, any resulting radiological hazards can be conservatively estimated with a high degree of confidence.

Relationships of Mechanical Loads, Cask Response, and Radiological Hazards

For accidents causing small structural strains in the cask containment shell, no radiological hazards would be expected since, for less than 0.2 percent strain, no significant permanent deformation would occur in the containment shell.

Strains in the 0.2- to 2-percent or the 2- to 30-percent ranges were presumed to cause containment functional failure, but without gross rupture of the containment (see figure on opposite page). The lack of any gross rupture is a reasonable expectation based on the known ductility (that is, the ability to stretch without fracturing) of the stainless steel material typically used in cask containment shells. At these strain levels, however, the impact loads could cause the lead gamma shield material to "slump." Where voids or gaps in the shield occur, radioactivity inside the cask could increase radiation levels outside the cask (see figure on page 19).

The major difference between accidents causing 0.2- to 2-percent strain as opposed to 2- to 30-percent strain involves the behavior of the fuel rod cladding that contains the spent fuel within the cask. The lower range was assumed to cause failure of up to 10 percent of the fuel rod cladding, whereas at the higher range, all rod claddings are assumed to fail. In either case, experimental information on radioactive releases from failed fuel rods is used to establish the fraction of gaseous, volatile, and solid radioactive material that could escape from each fuel rod. For the purpose of this study, all of this material was assumed to be released from the cask, although in reality, a large but undefinable fraction would "plate out" or adhere to surfaces within the cask.

What Types of Radiological Hazards Could Be Possible in Transportation Accidents?

The fuel assemblies used in commercial power reactors contain solid ceramic uranium oxide (UO_2) fuel pellets. During reactor operation, the uranium fuel fissions creating radioactive fission and activation products. Physically, most of the radioactive material remains in solid form within the pellets, although the pellets may exhibit some degree of fracturing. However, a small fraction of the fission products are gases or are in volatile form (the amount of volatiles being dependent on temperature). The radiological hazards that could conceivably be created by this material can occur through two distinct cask-damage mechanisms: (1) a release of material from a damaged cask or (2) an increase in the external radiation level emanating from material within the cask.

Material releases can occur in gaseous, volatile, or in solid form. The solids can be small airborne particles or larger pieces. Solid particles that could be inhaled can pose a significant hazard to people.

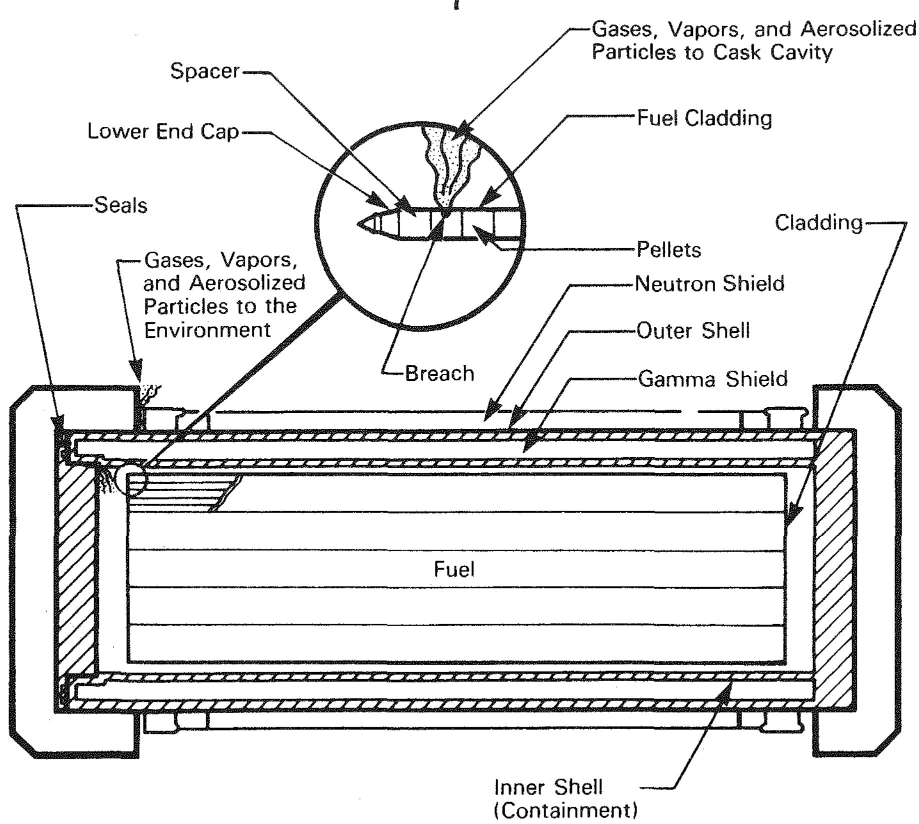
Increased radiation levels from material still within the cask could occur as the result of voids in the cask shielding due to mechanical forces or temperatures high enough to cause shield materials to melt.

Typical Radioactive Material Release Pathway

Presumed if either:

(1) Cask containment vessel strain between 0.2 and 30 percent, or

(2) Centerline gamma shield temperature between 500°F and 1050°F



CASK CHARACTERISTICS AND RESPONSES

The radiological hazards from accidents causing cask strains greater than 30 percent could not be precisely predicted because of the extensive and potentially varied nature of cask and spent fuel damage. In these situations, all gaseous material was presumed to be released while radioactive material in volatile and solid form was arbitrarily assumed to increase by a factor of 10 over the values predicted for accidents causing strain in the range of 2 to 30 percent. Only a very small fraction of truck or rail accidents, beyond any known accidents, could be severe enough to cause strains greater than 30 percent in the cask containment shell.

Relationships of Thermal Loads, Cask Response, and Radiological Hazards

Fires resulting from transportation accidents can affect a spent fuel cask and its contents. If the fire does not cause 500°F temperatures at the cask shield centerline, no radiological hazard would be expected since cask structural components are not susceptible to thermal deterioration or damage at temperatures below this level.

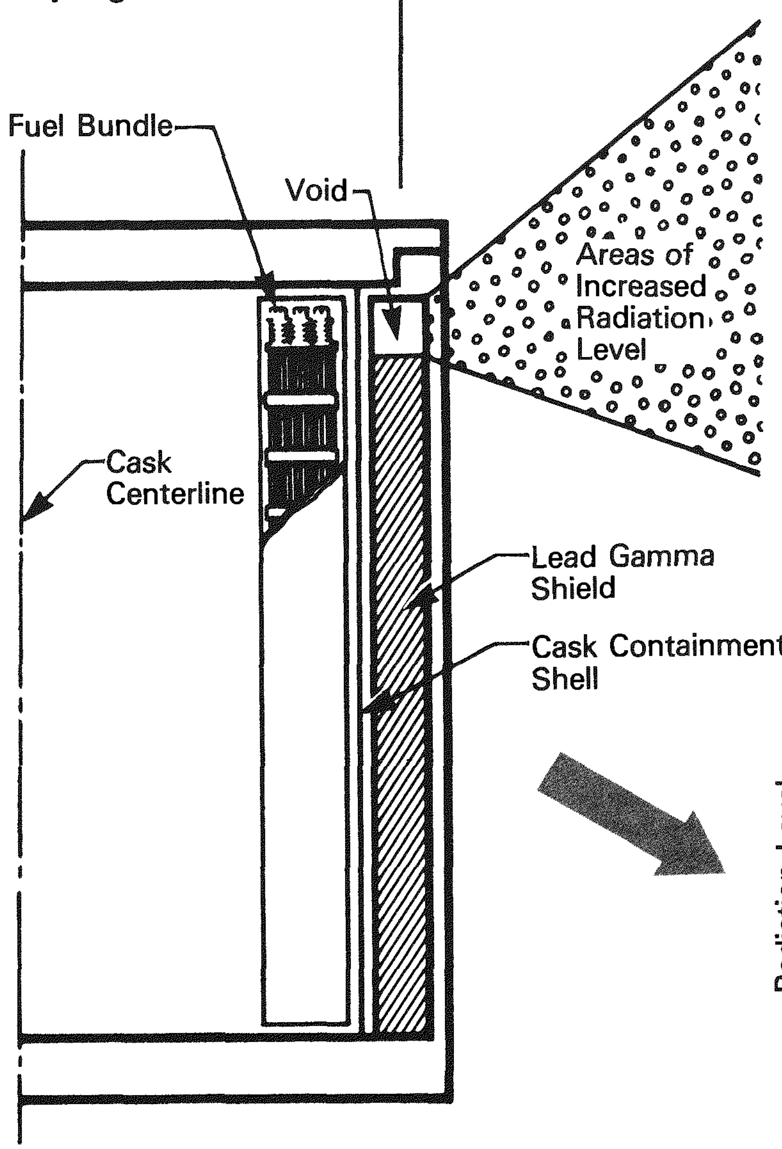
If temperatures at the shield centerline should reach between 500°F and 600°F, certain cask seal materials could degrade and lose their capacity to function. The spent fuel within the cask, however, would not reach temperatures high enough to fail the fuel rod cladding material. As a result, any potential radiological hazard created by a release of radioactive material from a cask would be limited to gaseous and volatile materials that have escaped from fuel rods whose cladding has failed during or before the accident for reasons other than the fire. Based on past experience, 3 percent of the fuel rods in a shipment were assumed to have cracks or breaks as a result of their use in the reactor, handling and storage before shipment, or vibrational loads during normal shipment.

At centerline shield temperatures between 600°F and 650°F, two types of radiological hazard could be created if lead is used as the gamma shield material (as is the case for the representative cask designs). Lead melts at 621°F and expands in volume during the melting process. This expansion can cause structural stresses that can result in loss of the cask's containment function. When the lead cools and resolidifies, its contraction can cause voids or gaps to form in the gamma shield. These gaps degrade cask shielding capabilities and so increase radiation levels outside the cask, as shown in the figure on the opposite page. In this study, a cask's loss of shielding capability was calculated as a function of temperature. A cask configuration that maximizes lead slump and subsequent voids, thereby maximizing radiation levels outside the casks, was also assumed.

Between 650°F and 1050°F, release of radioactive material from the cask or increased radiation levels outside the cask from contained material are more likely to occur and the magnitude of the resulting hazard could become larger. The major factor affecting the potential radiological hazard is the fraction of fuel rods experiencing cladding failures. For shield temperatures in this range, fuel rod temperatures can cause cladding failures; therefore, any radioactive material in mobile form could be released from the fuel to the cask. If cask containment is compromised, this material could reach the environment. Experimental information on the release of radioactivity from spent fuel has been used to estimate the magnitude of the potential radiological hazard. The conservative assumption was made that any material released inside the cask would escape from the cask to the environment.

If centerline shield temperatures exceed 1050°F, a cask's functional capabilities could be affected by several complex chemical, thermal, and structural processes that cannot be precisely predicted. In these situations, all gaseous radioactive material was presumed released to the environment whereas the release of radioactive material in volatile or solid form was arbitrarily assumed to increase by a factor of 10 over values

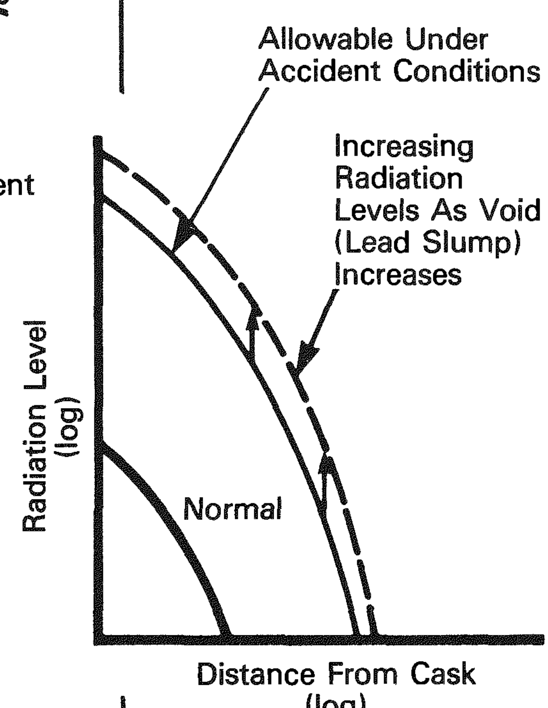
Typical Radiation Level Increase as a Result of Lead (Gamma Shield) Slumping



Presumed if either:

(1) Cask containment vessel strain exceeds 0.2 percent, or

(2) Centerline gamma shield (lead) temperature exceeds 600°F



assigned for temperatures in the 650°F to 1050°F range. As is the case for accidents causing extremely large structural strains, no historical truck or rail accident could be specifically identified that would have the potential to cause shield temperatures above 1050°F.

Cask Damage—What Accident Conditions Are Important and How Are They Defined?

Damage Caused by Mechanical Loads

The most important accident conditions used to define the mechanical loads imposed on a cask during an accident are those associated with various impacts. Because of the large weight, hardness, and rigidity of spent fuel casks, loads caused by crushing, by projectiles, or by other mechanisms have been demonstrated to be far less damaging than loads caused by impacts with hard, massive objects. As in any impact involving a motor vehicle or train, the damage sustained would depend on vehicle speed, the angle of impact (a head-on or a side-swiping impact), the hardness and massiveness of the object struck, and the orientation of the vehicle or object at the time of impact (front, rear, or side impact).

● Velocity at Impact

Potential cask velocities on impact were principally based on records of truck and rail accidents. The truck information shown on page 6 was derived from a sample of truck accidents causing fatalities or injuries reported by the California Highway Patrol. The rail information was derived from mainline accident data available from the Federal Railroad Administration. For accidents involving falls, the velocity of impact was based principally on a survey of bridge heights along a typical section of interstate highway. The velocity of trains involved in truck impacts was derived from rail-highway grade-crossing accident information.

● Angle of Impact

The angle of impact between a cask-carrying truck or rail car and the object or surface hit was estimated for each of the accident scenarios shown on pages 7 and 9. For example, head-on impacts with objects such as bridge abutments and columns were estimated to be far more likely than a side-swiping impact. Specifically, about 40 percent of all impacts with columns or abutments were assumed to occur at an angle less than 20° from head on. About 21 percent were estimated to occur within 10° of head on.

● Hardness of Object Struck

The hardness and massiveness of the object struck was determined, for the most part, by the information from the accident scenarios described on pages 7 and 9. Surfaces, such as hard rock, soft rock, and clay/silt, were modeled to provide a conservative representation of the variety of possible surfaces occurring within these three "earth" classifications.

● Orientation at Impact

Cask orientation on impact was estimated for each accident scenario similar to the process used to determine the possible angles of impact. For impacts with slopes or in impacts with other vehicles, any orientation was considered equally likely. For impacts with bridge columns and abutments, all orientations were considered possible, but the most likely orientation was estimated to involve an impact with the front end of the cask.

Damage Caused by Thermal Loads

The temperature of an accident-generated fire is the most important consideration in assessing potential cask functional degradation. The cumulative heat affecting a cask depends not only on the temperature and duration of the fire but also on the extent to which the cask is exposed. Data on fire temperatures and durations are not readily available in accident records; however, conservative estimates of fire temperatures and duration can be calculated based on pertinent information about the accident. For example, the thermal loading to a cask involved in a collision with a tanker carrying flammable cargo can be estimated by knowing the maximum volume carried by a typical tank truck and the nature of the product being shipped (for example, gasoline). For accidents involving trucks or trains carrying nonflammable cargo, knowledge of fuel tank volumes and the types and amounts of combustible material typical of truck or rail car construction is sufficient to allow similar conservative estimates to be made.

The only accident condition that could not be based, even qualitatively, on recorded accident data was the location of a cask relative to a fire resulting from a transportation accident. In the absence of recorded data, the researchers provided estimates that would be prudently conservative. The result was a presumption that in *all* accidents involving fires, a truck cask would be located at or within 31.5 feet of the fire center, the chance of any specific location within this range being equally likely. For rail casks, this location parameter was broadened slightly to encompass a range of 0 to 43 feet. Beyond these ranges, the thermal loads were not significant.

Fraction of Accidents Without Any Expected Radiological Hazards

For every 1000 truck or rail accidents involving spent fuel shipments that are capable of causing injury, death, or significant property damage, 994 would be expected to cause no significant radiological hazard. This estimate took into consideration cask responses to both mechanical and thermal accident loadings.

Mechanical Forces

● Responses to "Non-Severe" Transportation Accidents

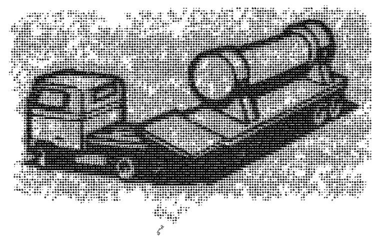
How the cask responded to mechanical forces was first considered for the objects identified in the accident scenarios described on pages 7 and 9. Estimates were made of the maximum forces that could be generated by each object or surface when struck at any impact velocity. These estimates were compared to the force necessary to cause a cask's containment structure to begin to permanently yield or deform. Through this comparison, many scenarios involving impacts with "soft" targets are shown to cause no functional damage to a cask (see opposite page). (These scenarios are shown without an asterisk on pages 7 and 9.) To illustrate this process, consider damage to a truck caused by a variety of collisions with animals and pedestrians; motorcycles; automobiles; other trucks; and, finally, fixed objects. Collisions with animals, pedestrians, motorcycles, and, to some degree, with automobiles typically cause little truck damage. These objects are "soft" relative to the truck, and as a result incur most of the damage sustained in the accident. Shipping casks are massive, heavy structures so that the objects so indicated on pages 7 and 9 are indeed "soft" relative to the cask.

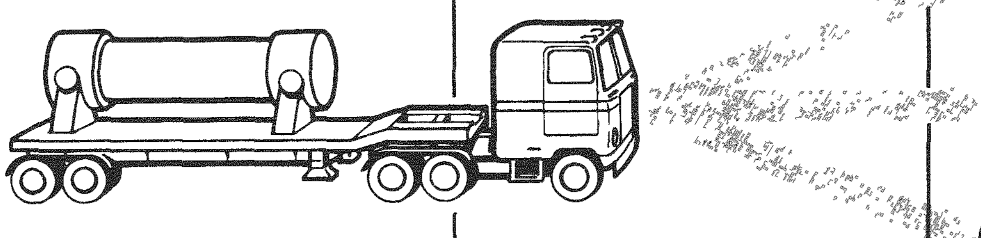
Summing the accident rates for truck accident scenarios involving impacts with a "soft" object provides a basis for concluding that these accidents describe about 950 out of every 1000 truck accidents. Such accidents would be unlikely to cause any functional cask damage. For the railroad accident scenarios, "soft" object impacts would occur in about 960 of every 1000 railroad accidents.

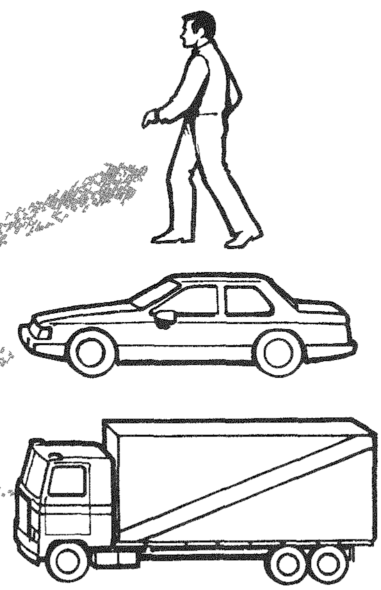
● Responses to "Hard" Object Impact Accidents

In accidents involving cask impacts with potentially massive and/or hard objects (see the scenarios marked with asterisks on pages 7 and 9), the possibility of cask functional damage is controlled by accident-specific parameters. For example, a truck carrying a spent fuel cask could hit a bridge column at 60 miles per hour. If the truck and cask side-swipe the column, however, the effective impact velocity (cask-vehicle velocity perpendicular to the column) could be only a few miles per hour and the resulting forces would be insufficient to damage the cask functionally. A second possibility is that the truck hits the bridge column or abutment head on but the truck and cask are traveling at less than 30 mph. Because current regulations require that a cask be subjected to a 30-mph impact on an unyielding surface without sustaining unacceptable damage, any impact of less than 30 mph on a generally flat surface would not be expected to cause functional damage. When these combinations of possible accident parameters are taken into account, at least 44 out of every 50 accidents involving impacts with "non-soft" objects or surfaces would be expected to cause no functional damage to a cask. The same outcome is anticipated for railroad accidents: conversely stated, a maximum of about 6 accidents out of every 1000 have the potential to cause some degree of cask functional damage.

Accident Scenarios Generating Mechanical Forces Incapable of Causing Functional Cask Damage

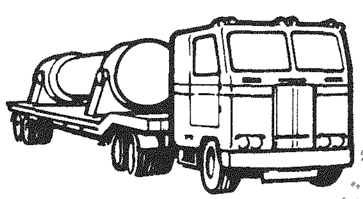


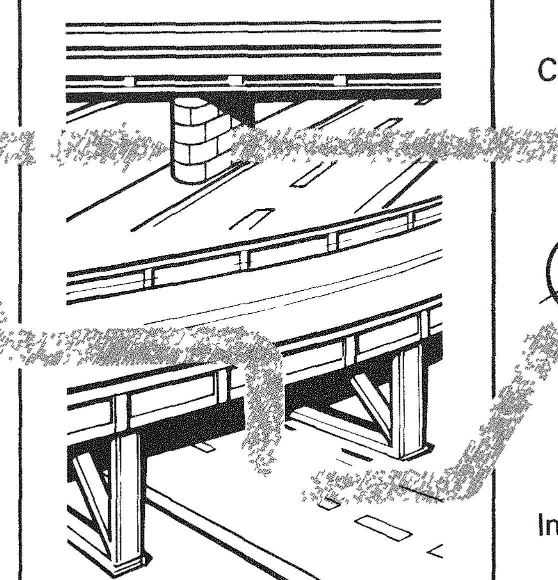


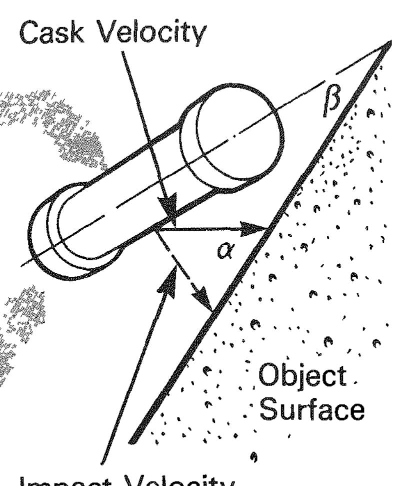


~950 of Every 1000 Accidents

- "Soft" Target Vis-a-Vis Spent Fuel Cask







~44 of Remaining 50 Accidents

One or More of the Following Apply:

- Velocity Too Low
- Impact Angle Too Shallow

Conclusion:

994 of Every 1000 Truck Accidents Generate Mechanical Forces Incapable of Causing Cask Functional Damage.

α = Impact Angle

β = Cask Orientation Angle

Thermal Forces

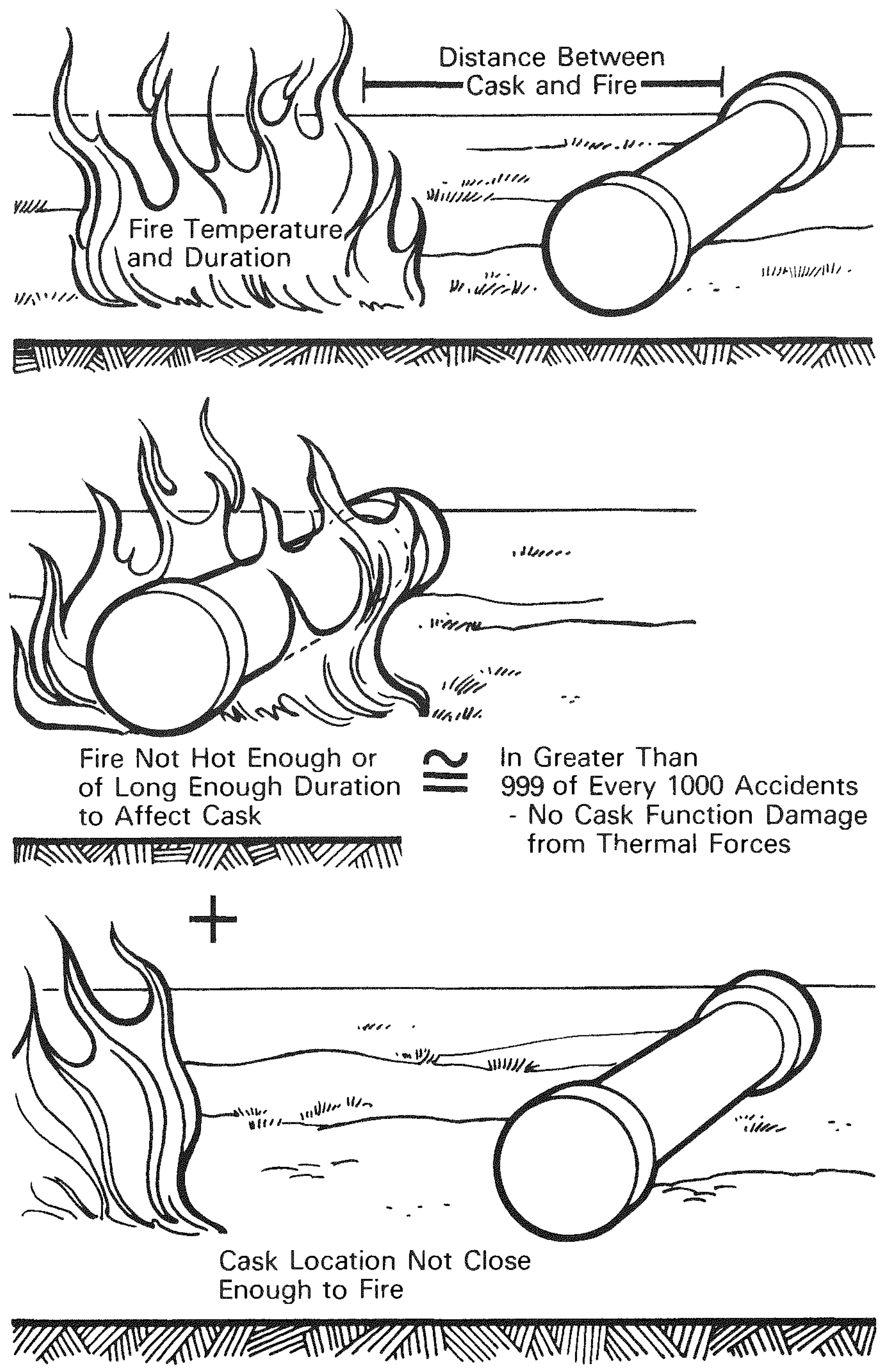
Cask damage from fires could cause melting of the lead shield or degradation of the closure seal. Either form of damage requires that the affected component reach temperatures in excess of 500°F. The mass and heat capacity of spent fuel casks are large. For a truck cask to reach such a temperature, it would have to be engulfed in a 1700°F fire for over an hour. For the larger representative rail cask to sustain equivalent damage, it would have to be engulfed for an estimated 1.35 hours. With few exceptions, only about 1% of the accidents in the truck and rail accident scenarios listed on pages 7 and 9 involve fires. Many of these fires would be fed by diesel or gasoline fuel from the truck or other vehicle involved in a highway accident, or from diesel fuel, lubricants, and rail car structural materials in railroad accident scenarios. These types of fires would not be expected to generate the heat necessary to cause functional cask damage. Furthermore, these types of fires are generally localized and not likely to completely engulf a cask over 16 feet long and 5 feet in diameter. The potential for functional cask damage from fires is therefore limited to accidents involving tanker trucks, locomotives, and tank cars with large quantities of flammable materials.

The approach taken to calculate cask responses to fires was to determine the likelihood that a fire would occur given a specific truck or train accident scenario defined on pages 7 and 9. Each scenario was assigned one of eight fire duration estimates (five for truck and three for rail accidents), two of which are shown on the upper figure on page 8. For rail accidents, a significant fraction of fires were assumed to have long durations (1 of 8 for the accident scenarios illustrated on page 9 were assumed to last longer than 1 hour). For truck accidents with other trucks or with trains, a similar fraction of fires exceeded 1 hour. Only for truck accidents involving no collision, a collision with a fixed object or a collision with an automobile were the fire durations limited so that only about 1 percent or less exceeded 1 hour. This assessment reflects the likelihood that fire durations would be limited by the amount of fuel in the fuel tanks of the vehicle involved in the accident.

These estimates were chosen conservatively because of the lack of actual accident data. The likelihood distribution applicable to fire temperatures is shown in the bottom figure on page 8. A large fraction of fires were assigned temperatures in excess of those typical in such accidents.

The fire temperatures and duration parameters, when considered with the potential for cask involvement in any accident-caused fire, resulted in the prediction that less than 1 of every 1000 truck or rail accidents has the potential to cause a fire capable of compromising cask safety. This conclusion is illustrated on the opposite page.

Accident Scenarios Generating Thermal Forces Incapable of Causing Functional Cask Damage



Potential Radiological Hazards Resulting From Functional Cask Damage

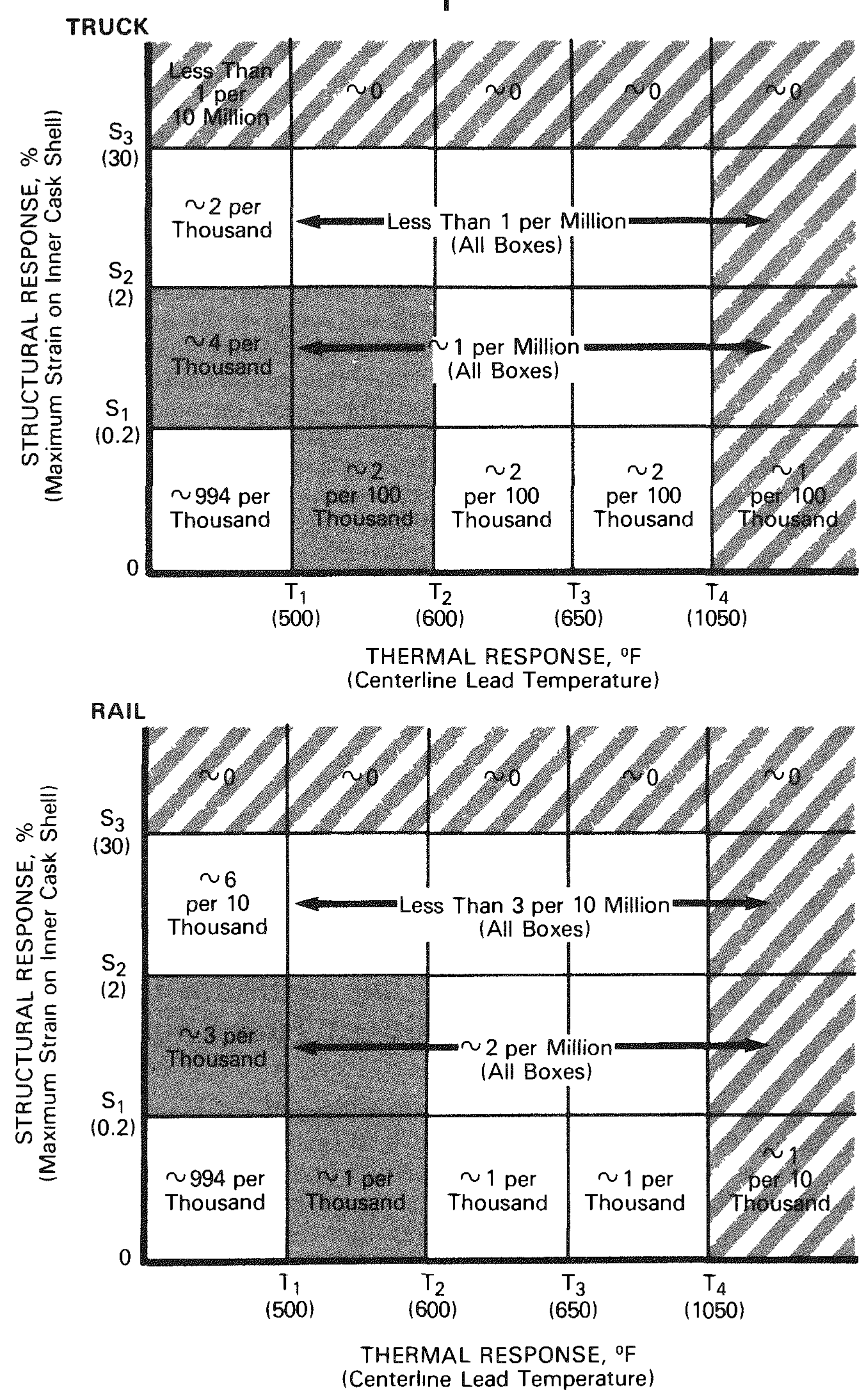
The evaluations described on pages 22 through 25 indicate that less than 6 of every 1000 truck accidents and 6 of every 1000 rail accidents could cause some functional cask damage. Damage to the cask could lead in turn to radiological hazards caused by either (1) the release of radioactive material from the cask's containment, or (2) an increased level of radiation emanating from the spent fuel within the cask caused by a degradation in a cask's shielding. The magnitude of any radiological hazard will vary depending on the extent of the cask's damage—the hazard tending to increase in magnitude as cask damage increases. In order to evaluate this variability in the potential hazard, three broad areas of cask response were characterized (see the figure on the opposite page).

Most of the accidents capable of causing any functional cask damage produce the limited responses shown within the gray area of the figure. In fact, of the 6 truck accidents out of every 1000 capable of causing any functional damage, about 4 are estimated to result in a cask response within this region. Similarly, 4 of the 6 *damage-producing rail accidents* are estimated to generate similar levels of damage. In this gray area, containment vessel structural damage is limited (to strains of less than 2 percent) and cask gamma radiation shield temperatures within the body of the cask are typically below melting temperatures (less than 600°F compared with the lead-melt temperature of 621°F). Note that other casks which do not use lead as a shield material would be expected to experience little, if any, shield damage. At this level of response, any radioactive materials released from the cask would exist as a gas and only a small fraction would occur either in volatile form or as small solid particles in an aerosol. Furthermore, little degradation of the cask's shielding would be expected since the mechanical and thermal forces imposed on the cask are insufficient to cause significant shield "slump" or voiding. In quantifying the potential magnitude of any radiological release created by responses in this area, researchers estimated that the magnitude of any release was likely to be *less* than compliance values applied to casks after they have been subjected to the hypothetical accident conditions described on page 5.

In the large open area, structural damage to a cask's containment could be significant, although gross rupture of the cask's containment shell would not be expected. The heat could melt lead in the shield, resulting in voids and increased external radiation levels. For cask responses in the large open area, radioactive material releases and/or external radiation levels potentially could slightly exceed existing regulatory compliance values. Just about 2 of every 1000 truck and rail accidents involving a spent fuel shipment are conservatively predicted to be capable of causing this level of radiological hazard.

Finally, only about 1 in every 100,000 truck accidents and 1 in every 10,000 rail accidents are calculated to lead to cask damage as described in the outer ring of response regions. No documented accident can be specifically identified that can cause this degree of cask damage. As indicated on pages 16 through 20, the radiological consequences of events in the outer ring were hypothesized because of the extensive and potentially varied nature of cask and spent fuel damage. Similarly, the potential for a loss of the cask's subcriticality function would be expected to be restricted to a small fraction of the "outer ring-type events" in which sufficient quantities of water were physically present.

Fraction of Truck and Rail Accidents Involving Spent Fuel Shipments that Cause Cask Responses Within Each Response Region



Note Numbers have been rounded off.

POTENTIAL HAZARDS AND RISK

Interpretation of the Relationship Between Potential Radiological Hazards and Real-World Severe Accidents

Predicting the likelihood and magnitude of any radiological hazard in a severe transportation accident is not an exact science. The forces applied to the spent fuel shipment in extremely severe accidents are based on extrapolations of historical accident data, the evidence from physical tests, and predictions from engineering models using conservative assumptions. What is clear is that as the severity of accidents increases, the extent of possible damage to casks and spent fuel also increases.

This summary report has described the processes and results used to assess the level of safety for spent fuel shipments. To better understand the results, two further interpretations of the level of safety can be made. First, an illustration of the relationship between potential radiological hazards and some understandable accident parameters is provided in the illustration on the opposite page. The illustration applies to truck shipments of spent fuel subjected to mechanical forces. The expected yearly accident event frequencies, indicated on the figure, include consideration of predicted spent fuel shipment activity and a truck accident rate of 6.4 accidents per million truck miles. It is important to remember that the statements on event likelihoods apply to the performance of the defined representative cask designs—real cask designs are expected to provide a greater level of safety in transportation accidents.

The second interpretation involves the prediction of the performance of the representative cask designs if they had been involved in certain historically documented, severe transportation accidents. Four specific events were selected from about 400 severe accidents that, in turn, were selected from a much broader DOT data base. The description of the four events and the predictions of cask response are illustrated on a portion of the figure on the opposite page.

Together, these results are believed to present a fair picture of the minimum level of safety provided during shipments of spent fuel. The reader is encouraged to refer to the LLNL report for a complete interpretation of the studies approach and results.

Risk Estimate for Spent Fuel Shipments

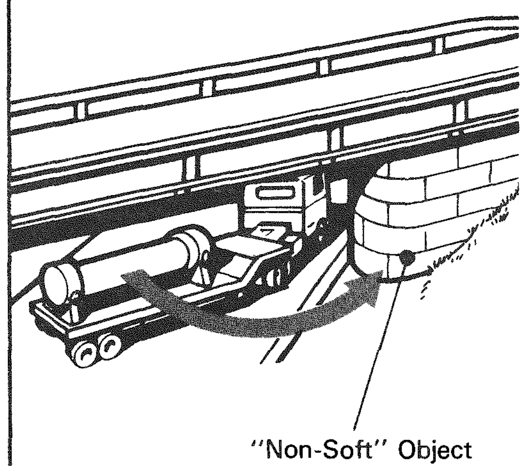
"Risk" and "expected value" are two of several measures used to predict future occurrences based on past experience in fields ranging from safety to sports. In this study, historical information on truck and rail accidents was supplemented by route survey data to predict the occurrence frequency of severe transportation accidents. Engineering models were then used to predict how a spent fuel shipment would respond in these accidents and what magnitude of radiological hazard might be created. A risk measure was determined by multiplying the magnitude of each potential hazard by its occurrence frequency and summing all the resulting values.

This type of risk measure has a regulatory precedent applicable to this study. In December 1977, a study that evaluated the risk for all radioactive material shipments, including spent fuel, was published as a Final Environmental Statement (FES).* The evaluations contained in the FES indicated a radiological risk from transportation accidents of one latent cancer fatality every 59 years for all projected 1985 radioactive material shipments. Most of this risk was associated with shipments of medical radioisotopes. The contribution from spent fuel shipments was 2.5 percent of this estimate.

* "Transportation of Radioactive Material by Air and Other Modes," NUREG-0170, December 1977.

Accident Scenarios Generating Mechanical Forces Potentially Capable of Causing a Radiological Hazard

Occurrence Rate
= 6 Events per 1000 Accidents
= One Accident Expected Every 10 Years (Assuming ∾3 Million Shipment Miles Per Year)



POTENTIAL MAGNITUDE OF RADIOLOGICAL HAZARD

Cask Velocity Normal to Surface or Object - Between 32 mph and 50 mph

4 Events per 1000 Accidents or 1 Expected Event Every 14 Years

- Material Releases (Primarily Gases and Volatiles) Less Than Compliance Values*
- No Significant Increase in External Radiation Levels

∾2 Events per 1000 Accidents or 1 Expected Event Every 35 Years

Cask Velocity Normal to Surface or Object - Between 50 mph and 75 mph

- Material Releases (Primarily Gases and Volatiles) Could Exceed Compliance Values* by a Small Factor (i.e., 2 or 3 Times)
- External Radiation Levels Could Equal or Slightly Exceed (by a Factor of∾3) Compliance Values*

Less Than 1 Event per 10 Million Accidents or No Expected Events During Repository Shipments

Cask Velocity Normal to Surface or Object - Exceeds 75 mph

- Material Releases Estimated to Exceed Compliance Values* by About a Factor of 20 Dependent on the Specifics of the Accident
- External Radiation Levels Estimated to Exceed Compliance Values* by a Factor of 30 Dependent on the Specifics of the Accident

*Compliance Values as Defined in Current Regulations

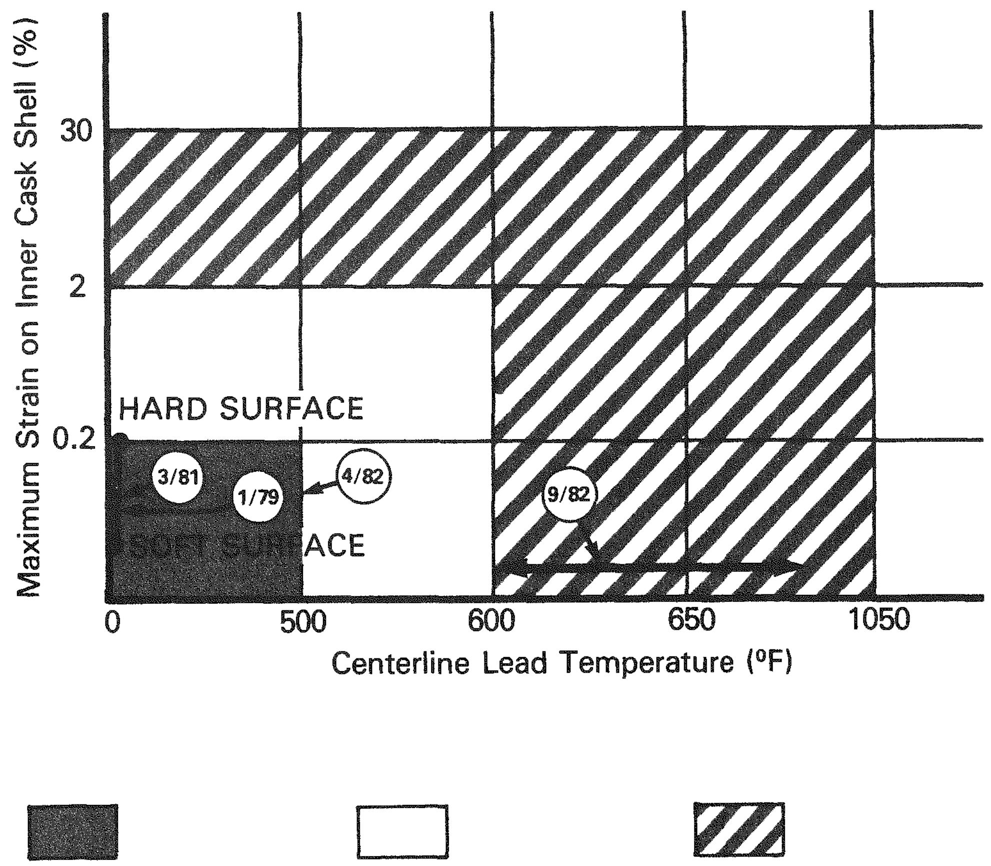
Predicted Cask Response to Selected Historical Accident Events

CALDECOTT TUNNEL FIRE - 4/82

- 3-Vehicle Collision — Gasoline Truck-Trailer, Bus and Automobile
- 8,800 Gallons of Gasoline
- Fire of 2 Hours and 42 Minutes - 40 Minutes ᵊ 1900°F

Predicted Cask Response

- No Significant Impact Damage - "Soft" Objects
- 45 Minutes ᵊ 1900°F Causes 500°F Centerline Temperature



No Radiological Hazard

Radiological Hazard Approximates Compliance Values*

Radiological Hazard Exceeds Compliance Values By Up to a Factor of 4

I-80 BRIDGE ACCIDENT - 3/81

- Collision With Pickup Truck and Fall from 64-Foot High Bridge Onto Soil

Predicted Cask Response

- 44 mph Impact
- No Significant Impact Damage

LIVINGSTON TRAIN FIRE - 9/82

- Derailment of Vinyl Chloride/ Petroleum Tank Cars
- Large Fires for Several Days Moved Over Large Area
- 2 Explosions

Predicted Cask Response

- Maximum Probable Cask Exposure to Petroleum Fire - Between 82 Hours and 4 Days
- No Significant Damage from Explosion
- Centerline Shield Temperature Between 600°F and 720°F Dependent on Degree of Cask Involvement

DERAILMENT ON ALABAMA RIVER BRIDGE -1/79

- Plunge Off 75-Foot High Bridge
- Railcar Impacts Into Water and Mud

Predicted Cask Response

- 47 mph Impact in Soft Target
- No Significant Impact Damage

POTENTIAL HAZARDS AND RISK

In the FES, the predicted performance of radioactive material packages was based, for the most part, on engineering models and conservative engineering judgments. The LLNL study, on the other hand, focused entirely on spent fuel shipments and provided a detailed engineering analysis of package or cask performance under severe transportation accident conditions. The table on this page compares the results from the two studies.

The LLNL study included a more detailed approach to the calculation of radiological hazards that involved the consideration of releases of radioactive material as small inhalable particles. Any solid material release from a cask would require the creation of a direct release pathway from both the containment provided by the fuel rod and the cask (that is, a pathway much more direct than one needed for gaseous or volatile material releases). With the assumption of such a pathway and the presumed release of solid material,* the risk, as calculated in the LLNL study, is shown in the following table to be less than one-third of the values estimated in the FES. Therefore, to the extent that the Commission's conclusion on the adequacy of NRC regulations were initially valid and were dependent on the FES risk estimates, the LLNL study has not identified any increase in risk that would change the Commission's conclusion.

RISK RESULTS - COMPARISON WITH PAST FES EVALUATION

	FES (NUREG-0170) ESTIMATES	LLNL STUDY RESULTS
Fraction of Transportation Accidents Involving Spent Fuel Shipments Causing Any Radiological Hazard	0.09 (Truck) 0.20 (Rail)	0.006 (Truck) 0.006 (Rail)
Fraction of Transportation Accidents Involving Spent Fuel Shipments Causing Largest Estimated Radiological Hazard	0.004 (Truck) 0.002 (Rail)	0.00001 (Truck) 0.00013 (Rail)
Overall Annual Risk From Transportation Accidents Involving Spent Fuel Shipments	0.0004 Latent Cancer Fatalities Per Year	Less Than 1/3 of FES Value

*A shipping cask has been subjected to attack by explosive to evaluate cask and spent fuel response to a device 30 times larger in explosive weight than a typical anti-tank weapon. This device would carve an approximately 3-inch-diameter hole through the cask wall and contained spent fuel and is estimated to cause the release of 2/100,000 of the total fuel weight (~10 grams of fuel) in an inhalable form. No transportation accident can be identified that would impose anywhere near the energy per unit volume caused by this explosive attack.

Notes

DOE/RW-0065

Transporting Spent Nuclear Fuel: An Overview

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

March 1986

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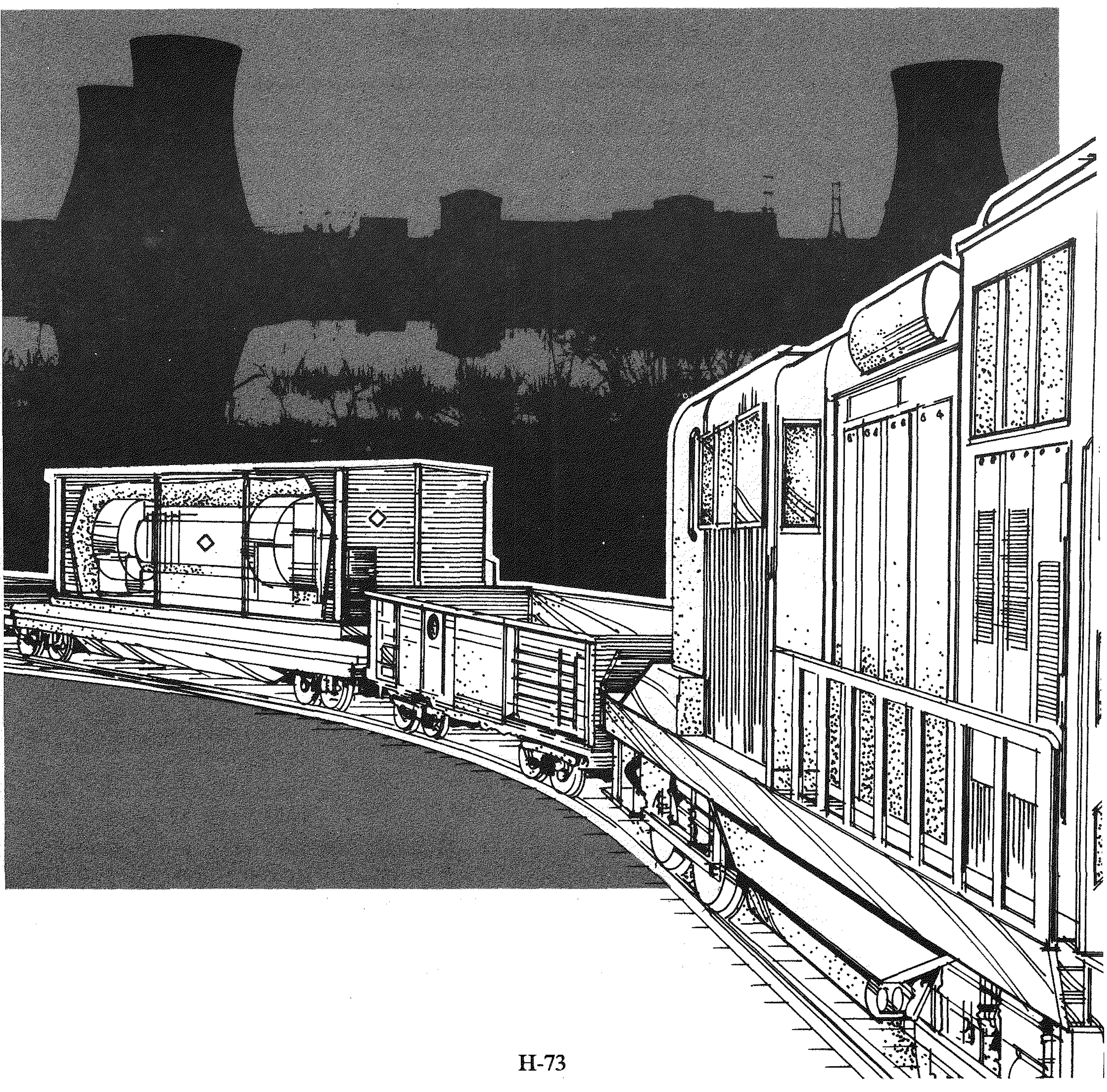


Introduction

Since the first nuclear power plant began generating electricity, nuclear planners have recognized the necessity to provide a safe method of storing and eventually disposing of the radioactive used or "spent" fuel after it is removed from the reactor. Over the years, a number of studies have examined alternative methods of high-level waste and spent fuel disposal. After systematic evaluation of several options, the U.S. Department of Energy (DOE) determined that isolation in deep geologic formations offered the safest and most effective method of disposal.

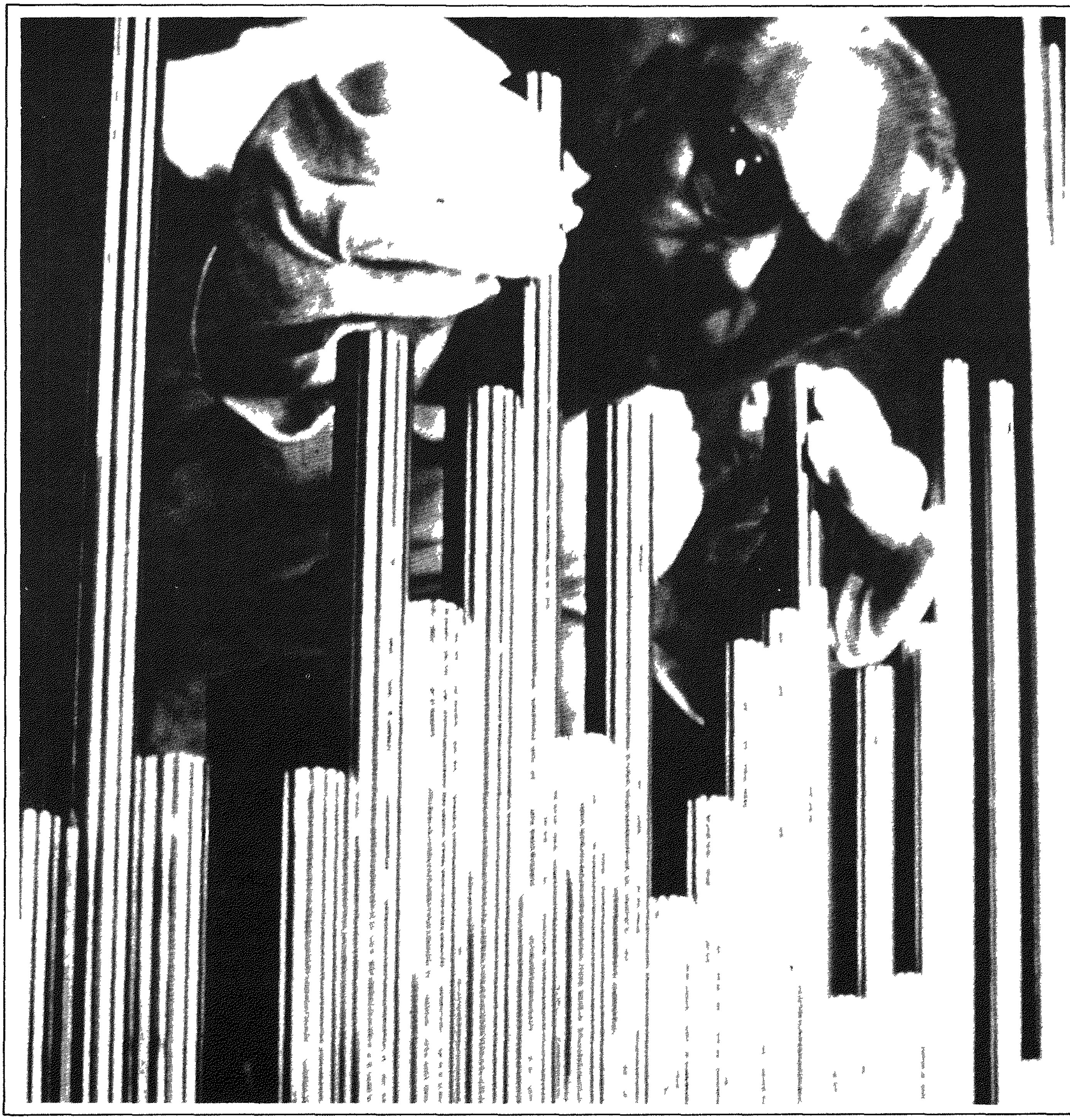
When Congress passed the Nuclear Waste Policy Act of 1982 (NWPA), the United States took a major step toward the goal of safe disposal of spent fuel and radioactive waste. This landmark legislation provides a comprehensive plan and schedule for establishing a national system of permanent waste disposal in deep underground repositories. A necessary element of this system is the transportation of the waste to the facilities developed under the NWPA.

The United States has a long history of transporting radioactive material. Commercial spent fuel has been shipped for over 20 years; high-level wastes from defense activities for an even longer period. These shipments have been made without fatalities or damage to the environment. The DOE is taking measures to ensure that this safety record continues. An extensive program is under way to develop equipment and procedures that can accommodate the expected increase in number of shipments when the first repository begins operation in the late 1990s.

Although high-level radioactive waste from both commercial and defense activities will be shipped to the repository, this booklet focuses on various aspects of transporting commercial spent fuel, which accounts for the majority of the material to be shipped. The booklet is intended to give the reader a basic understanding of the following:

- the reasons for transportation of spent nuclear fuel,
- the methods by which it is shipped,
- the safety and security precautions taken for its transportation,
- emergency response procedures in the event of an accident, and
- the DOE program to develop a system uniquely appropriate to NWPA transportation requirements.

Contents



A technician inspects the metal fuel rods that will be filled with ceramic pellets of uranium dioxide and placed inside a nuclear reactor's core After about 3 years of use, the rods are removed from the reactor and stored underwater at reactor sites Ultimately, this used or ' spent fuel will be transported to an underground geologic repository for disposal

What Is Spent Fuel And Why Must It Be Transported?

Small ceramic pellets of uranium dioxide comprise the fuel for a commercial nuclear power plant. The pellets, slightly larger than a wooden pencil eraser, are stacked inside metal tubes about 15 feet long and the diameter of a human finger. The sealed tubes, often called fuel rods, are bundled together into fuel assemblies and are placed in a nuclear reactor's core. A subsequent nuclear reaction creates heat that is used to generate electricity through a process similar to that used at a coal- or oil-fired power plant.

After about 3 years in the reactor, a fuel assembly can no longer generate enough heat to be effective and must be replaced. Approximately one-third of the fuel assemblies in a typical reactor are replaced each year.

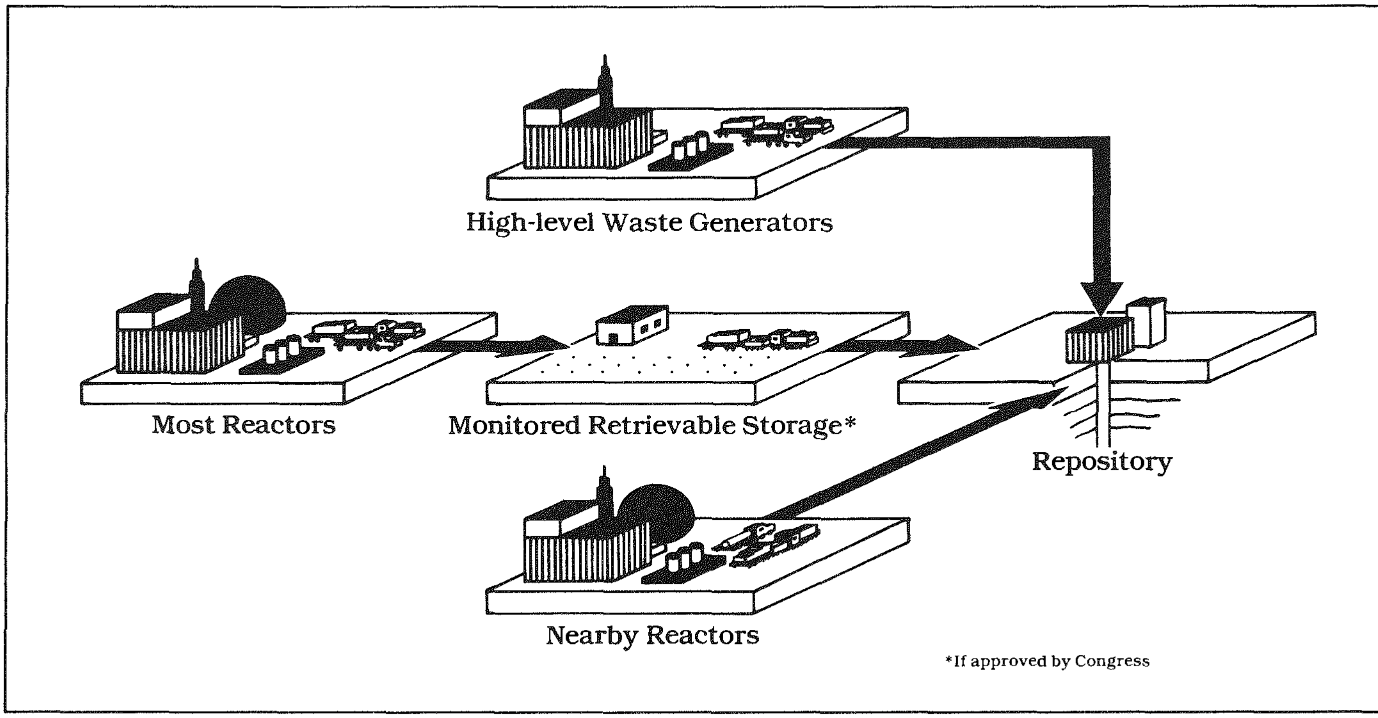
A used (spent) fuel assembly removed from the reactor still generates enough heat to keep a modest-size house warm and emits significant amounts of radiation. These factors create a need for stringent handling and storage procedures to protect public health and safety. (However, neither "fresh" nor "spent" fuel presents a nuclear explosion hazard, since it is physically impossible for the fuel to explode, either by accident or from sabotage.)

Because of the heat and radiation, the spent fuel assemblies are placed underwater in concrete, steel-lined storage pools at the power plant site. The water serves as both a radiation shield and a cooling medium to remove excess heat. With time, the radioactivity dissipates as heat. After 5 years the fuel assemblies are significantly less radioactive and produce little heat.

Federal Responsibility

Nuclear power plants in the United States have produced more than 40,000 spent fuel assemblies, which are currently in underwater storage at power plant sites around the country. Ultimately, under the terms of the Nuclear Waste Policy Act of 1982 (NWPA), this spent fuel will be buried deep underground in a federal repository—large, mined vaults—where a combination of man-made and natural barriers will isolate the material from the human environment for thousands of years.

The NWPA established federal responsibility for the management and disposal of high-level radioactive waste and spent fuel, requiring the Department of Energy (DOE) to begin accepting spent fuel from utilities for final disposal in 1998.



Federal legislation gives DOE the responsibility for transporting spent fuel from reactors to a geologic repository or to any federal handling or storage facility, such as a monitored retrievable storage (MRS) facility, if such a facility is approved by Congress.

The NWPA also made the DOE responsible for transportation of spent fuel from reactors to the repository or to any other federal handling or storage facility developed under the NWPA.

The DOE is now developing the transportation system needed to handle the increased number of spent fuel shipments that are scheduled to begin in the late 1990s. The DOE objective is to ensure that a safe, economic, and publicly acceptable nuclear waste transportation system is in place when needed.

Between now and the estimated time of spent fuel shipments to a repository, however, other factors related to the NWPA and dwindling storage capacities at reactor sites could require interim transportation of spent fuel. Two of these factors are described below:

- Several utilities are expected to exhaust their existing spent fuel storage capacities before 1998. Unless additional storage capacity becomes available or new storage methods are developed, these utilities could be forced to shut down their nuclear power plants until the problem is solved. To avert this situation, some utilities that own more than one nuclear power plant will ship spent fuel from one reactor's almost-full storage pool to another reactor's less-crowded one. In addition, spent fuel could also be shipped to other storage facilities. These transshipments are the responsibility of the utilities. The use of dry storage casks is also being investigated by the utilities as a means of adding incremental storage capacity at the power plants.
- The NWPA directed the DOE to study the need for and feasibility of monitored retrievable storage (MRS) facilities as part of the federal nuclear waste management system. After studying this option, the DOE is proposing for congressional approval the construction of an MRS facility at a site in Tennessee, central to existing spent fuel inventories at power plants. If Congress approves, the MRS facility would serve as a centralized spent fuel and nuclear waste consolidation and packaging facility. Spent fuel would arrive by either rail or truck in heavily-shielded shipping containers (casks) that will have been certified by the Nuclear Regulatory Commission (NRC). The spent fuel rods would be removed from each fuel assembly and packed more closely (consolidated) before being sealed inside a cylindrical steel canister for disposal in a repository.

Who Is Responsible?

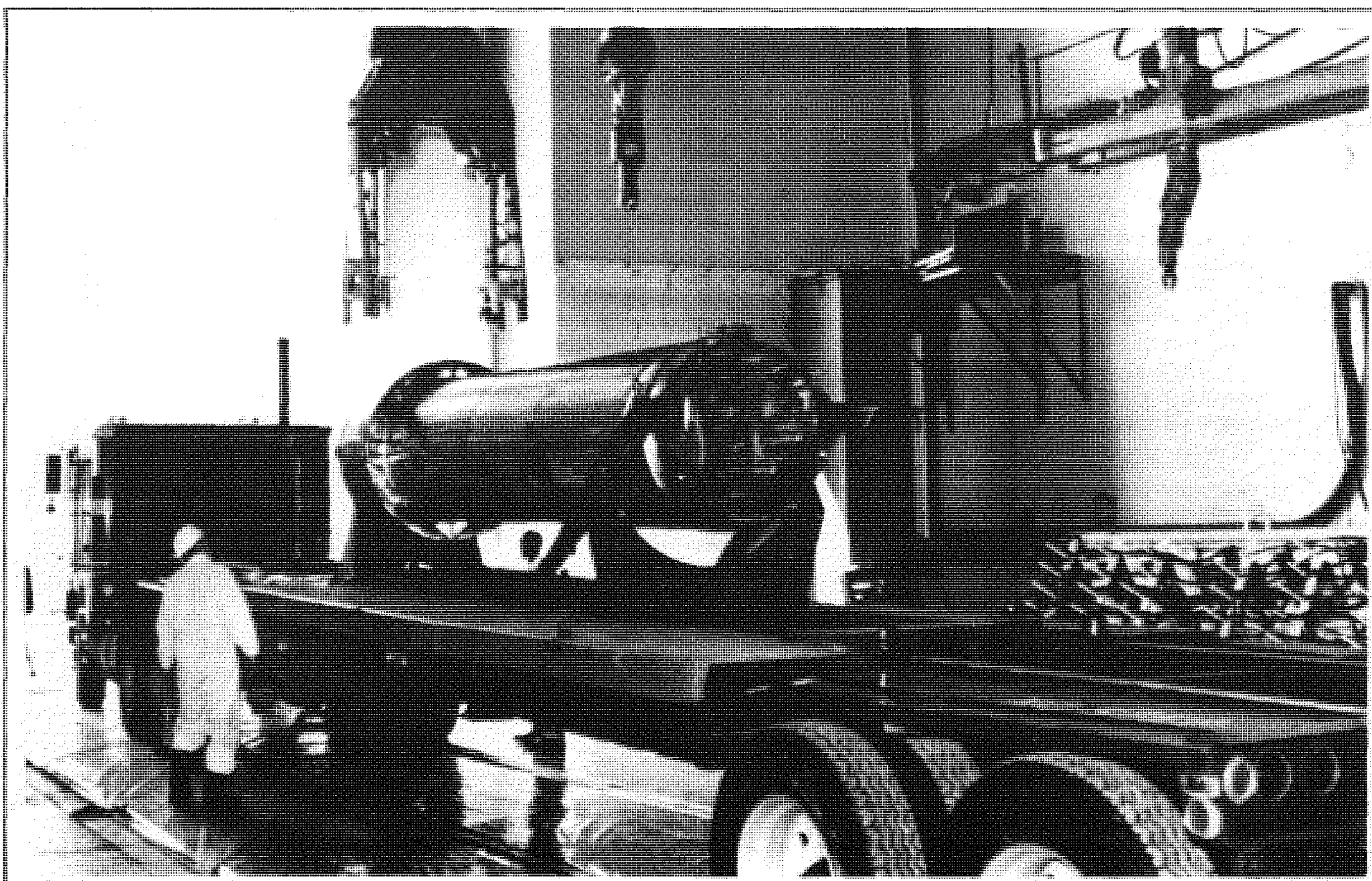
Three federal agencies will play key roles in the transportation of spent fuel under the NWPA:

- The **Department of Transportation**—The DOT regulates safe transportation of radioactive materials by all methods—rail, highway, water and air. In general, the DOT sets standards for the packaging and shipping of certain low-level radioactive material and the general labeling, handling, placarding, loading, and unloading requirements of all radioactive materials. The DOT is also responsible for setting the guidelines for the routing of shipments of nuclear fuel.
- The **Nuclear Regulatory Commission**—The NRC works closely with the DOT to regulate the transportation of radioactive materials. The NRC sets standards for packaging and containment of certain higher concentrations of radioactive materials and spent fuel, including larger quantities of special nuclear materials and spent fuel. The NRC will certify spent fuel shipping casks used by the DOE for commercial nuclear waste management. Additionally, the NRC sets regulations for protection of shipments of spent fuel from acts of sabotage or terrorism.
- The **Department of Energy**—The DOE's Office of Civilian Radioactive Waste Management (OCRWM) has been established, in accordance with the NWPA, to serve as the lead office for siting, constructing and operating nuclear waste repositories; transporting commercial spent fuel and high-level wastes; developing a proposal to construct a monitored retrievable storage facility; and aiding utilities in solving spent fuel storage problems. For NWPA activities, DOE will comply with all DOT and NRC requirements for transportation of commercial spent fuel.

State, tribal and local governments also have key responsibilities for participating in the planning for and operation of a safe and efficient system. State officials will be involved in inspection and enforcement activities. Generally, local fire and police personnel will be the first responders in the event of a transportation emergency.

Following the loading of the consolidated rods into the canisters, the spent fuel could either be temporarily stored at the MRS facility or shipped directly to the repository. When shipped to the repository, the canisters would be loaded into NRC-licensed shipping casks and shipped by dedicated trains.

Siting the MRS facility at a location central to the spent fuel inventory would have a major, positive impact on transportation. The shipments from the reactors would converge at the MRS facility after relatively short journeys. The consolidation that occurred at the MRS facility and the subsequent use of dedicated trains, which allows the use of larger spent fuel shipping casks than could be transported by truck, would reduce the total number of shipment miles for the nuclear waste management system. Reducing the number of miles spent fuel shipments travel, in turn, reduces the probability of accidents.



Spent fuel is transported inside heavily-shielded, metal shipping casks.

Transporting Spent Nuclear Fuel

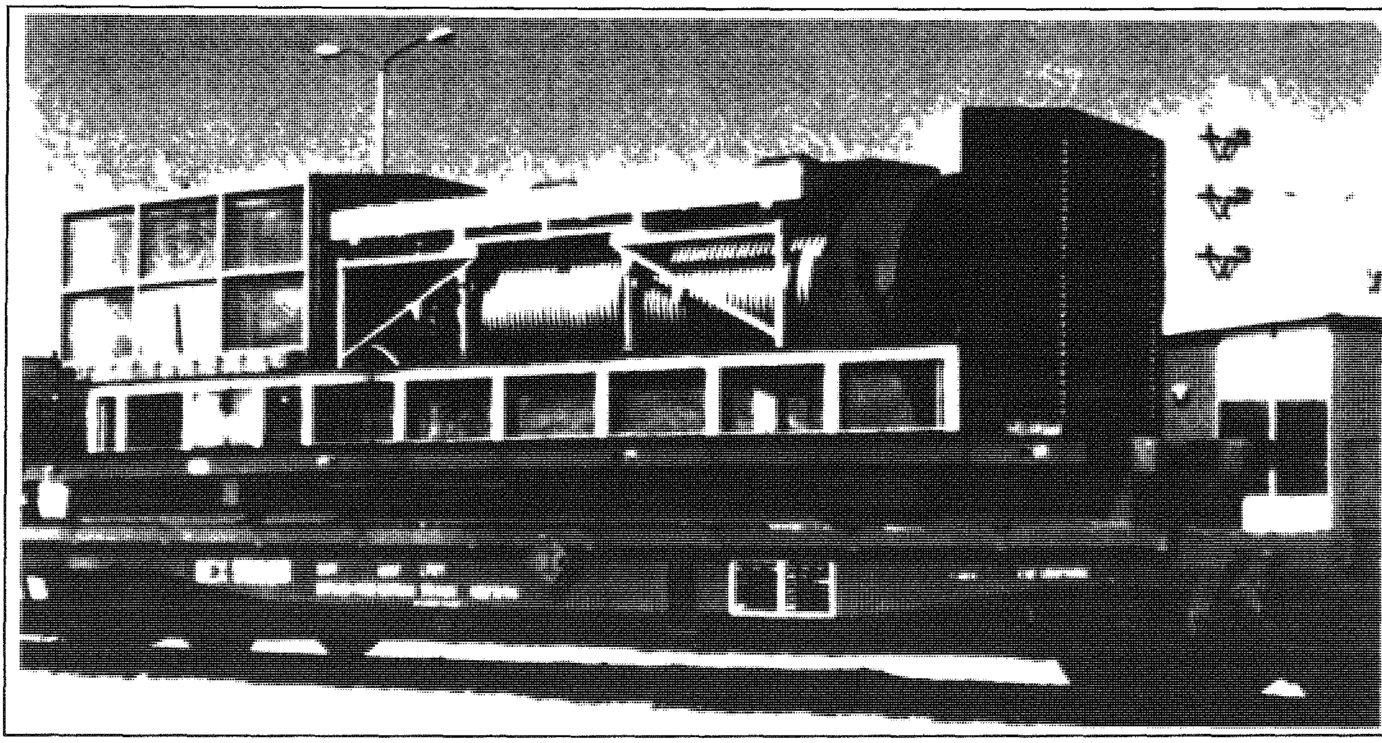
To provide an understanding of how waste will be transported in the late 1990s to a repository or other federal handling or storage facility developed under the NWPA, a projection of a typical nuclear waste shipment is provided in the following section. For this description, a shipment of spent fuel by truck to a repository is used as an example. Spent fuel will also be shipped by rail.

When spent fuel, which has been in temporary storage at the power plant site, is designated for disposal, the DOE will take title to the fuel. Highly-trained DOE service contractors will transport the waste to the repository or to other facilities, such as an MRS facility. The service contractors must show the DOE that they can fully comply with DOT, NRC, and valid state requirements governing such shipments. For example, the drivers of the shipment, who are employees of a service contractor, must have completed training and passed comprehensive tests. These tests are designed to ensure that the drivers understand the routing criteria, the federal regulations on transporting hazardous materials, the properties and hazards of radioactive shipments, and emergency procedures in case of accidents. Periodic retraining and testing are required at least every 2 years. At that time, the drivers' performance records are checked to monitor adherence to regulations.

Typical Shipments

As a first step in the truck transport of nuclear waste, an empty shipping cask is delivered to the power plant site, unloaded from the truck, and moved into the water pool where discharged spent fuel is being temporarily stored. The spent fuel is taken from its position in the spent fuel storage pool and loaded into the shipping cask by power plant workers using special hoists.

Before the spent fuel shipment leaves the power plant site, radiation and contamination surveys and administrative checklists must be completed and documented to show that the shipment fully complies with federal regulations, including those governing the allowable levels of heat and radiation on the cask surface and vehicle. Casks are attached to a truck trailer and may be enclosed in a protective metal barrier to prevent inadvertent or unauthorized access. Placards are attached to the truck cab and trailer, and labels are affixed to the cask to plainly identify the radioactive nature of the cargo. The shipper then issues a certificate to the carrier stating that the cask complies with all federal regulations and is ready for shipment.



Spent fuel can also be transported by rail

Finally, a comprehensive inspection is conducted by federal and state officials to verify that the cask, the vehicle, and all supporting equipment meet the safety requirements.

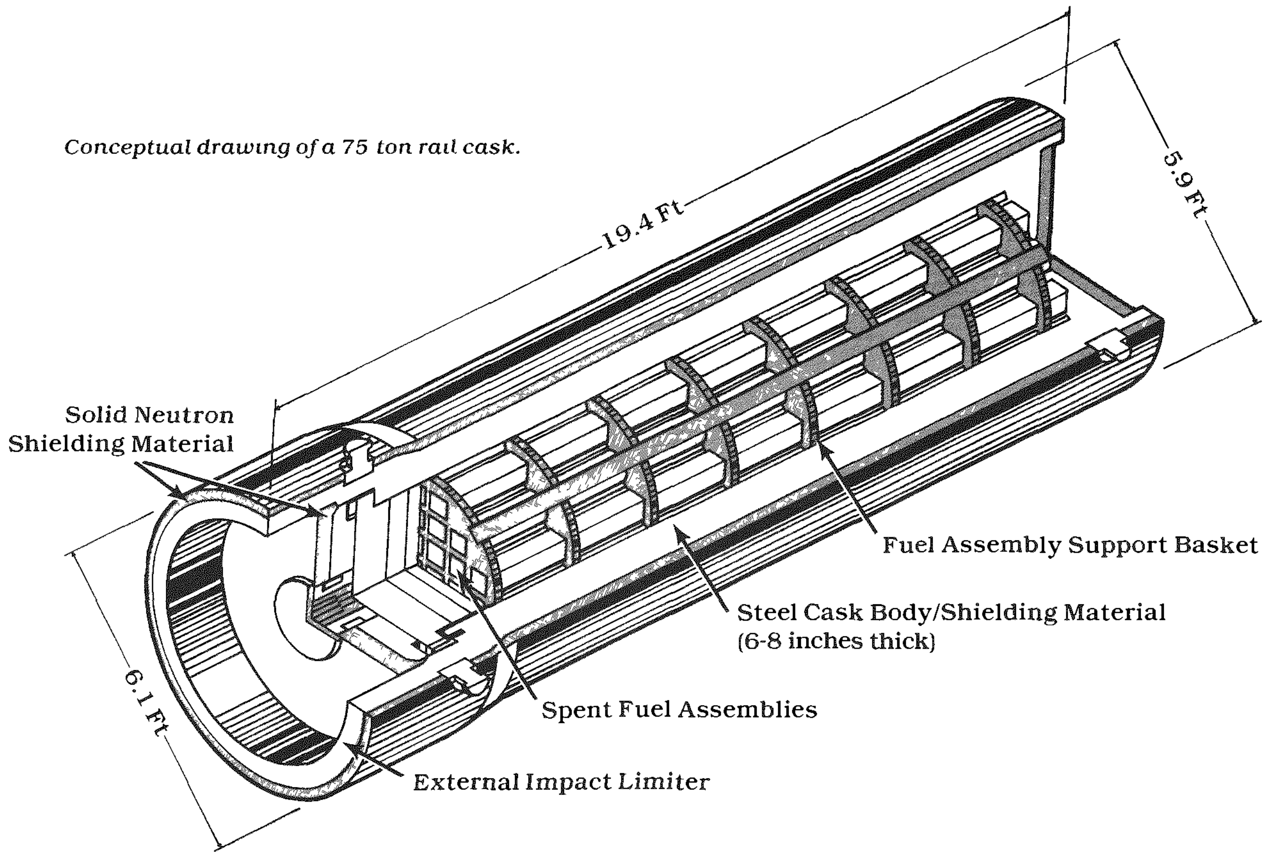
The truck and its attached cask are now ready for the road. Because the vehicle is an adaptation of conventional truck-trailer equipment and meets normal federal and state vehicle requirements, it can travel on the same highways and bridges as all other truck traffic.

Regulations issued by the DOT establish preferred routes as 1) interstate highways with use of bypasses and beltways around cities when available and 2) state-designated alternate routes selected through a process of consultation with other affected states and with tribal and local jurisdictions and following DOT guidelines. The driver must carry a written route plan in the truck. This route plan includes origin and destination points, the selected route, planned stops, estimated departure and arrival times, and telephone numbers for emergency assistance in each state through which the shipment will travel.

Spent fuel shippers licensed by the NRC are currently required to notify the governor or his designated representative in each state through which spent fuel is to be shipped—either by mail, 7 days before transport within or through the state (if by truck), or by messenger service, 4 days before. The shipper must also notify the state(s) by telephone if a shipment is cancelled or a schedule is changed. This notice to the affected states includes the planned route and schedules, shipment description, and the carrier's name and address. As a security measure, the NRC prohibits release of specific routing information to the public. The governor's office determines who in the state should have routing and schedule information. Also, the NRC requires shippers to notify the recipients of the spent fuel before each shipment, giving dates of shipment and expected arrival time at the recipient's facility.

To protect a spent fuel shipment against sabotage, the NRC requires additional appropriate physical security measures. Under certain conditions, escorts either follow the shipment or ride in the truck cab or in a railcar Other measures that help ensure security of the shipment include an on-board communications system and a vehicle immobilization capability (on trucks). The driver must not leave the vehicle unattended and should make stops only for food; fuel; driver rest; required state, DOT and NRC inspections; and any needed vehicle repairs.

Conceptual drawing of a 75 ton rail cask.



Transport Casks for Spent Nuclear Fuel

The transport cask or shipping cask is a primary protection against any potential exposure of radiation to the public and transportation workers. These special transport casks typically have 6- to 8-inch-thick walls which consist of a shielding material sandwiched between a steel outer shell and a stainless steel inner shell. The cask design provides for heat dissipation, containment, and shielding. The dimensions, configurations, and capacities vary, depending upon the specific cask requirements (e.g., for use on trucks or on trains or barges).

The designs for commercial spent fuel casks are subject to NRC review and certification. This review process verifies that the designs adhere to federal regulations. A cask must be designed to survive severe accident conditions with no radioactive material released except for contaminated gases in small amounts that would not pose any threat to health. NRC certification of a cask design lasts 5 years with the option for renewal for an additional 5 years During that time, users are required to perform prescribed maintenance and quality assurance inspections.

A variety of cask types and sizes is currently used to carry spent fuel. Lighter casks (25 to 40 tons) transport spent fuel by truck and hold one to seven assemblies. Heavier casks (up to 120 tons) with a capacity for up to 36 or more assemblies are designed for rail transport. Because of the weight of even the lightest casks, loading and unloading operations are performed with cranes, hoists, and other handling equipment.

It is expected that rail and truck casks based on new-generation design concepts will be used for shipping under the NWPA. Unlike casks of current design that accommodate spent fuel that has recently been removed from the reactor, casks for NWPA shipping will be designed for spent fuel that has been out of the reactor 5 to 10 years or more and is, therefore, both cooler and less radioactive. The advantage of the new-generation designs is that more spent fuel can be shipped per cask, resulting in fewer shipments. This has implications for reducing the potential for accidents—both radiological and non-radiological. It is possible that dual-purpose or multi-purpose casks will be used to accommodate more than one function (e.g., one cask can be used for storage, transportation, and perhaps even disposal).

Radiation and Routine Shipments

Everyone is exposed to numerous common sources of natural and man-made radiation. Two examples are radiation from cosmic rays and from radioactive materials in the earth's crust. Cosmic radiation increases with altitude. Thus, a person living in the United States could receive radiation of 100 to 200 millirem* per year, depending on the altitude and geology of the area. In addition, medical and dental X-rays expose patients to an average 92 millirem of low-level radiation each year. People in some occupations are exposed to even more radiation without apparent danger to their health. For example, intercontinental flight attendants get about 460 millirem during about 840 hours of flying per year.

According to DOE calculations, potential exposure to people living near (100 feet to half a mile) the route of a vehicle traveling at 15 miles per hour (mph) and carrying spent fuel is 0.000001 to 0.001 millirem per shipment.

*A millirem is equal to one-thousandth of a rem. A rem (roentgen equivalent in man) is a measurement of the effects a dose of radiation would have on human tissues. The guidelines that have been established by the International Commission on Radiological Protection state that those who are exposed to radiation in the course of their occupation shall not receive a dose greater than 5000 millirem per year. For a member of the public, the dose should not exceed 500 millirem (these doses do not include that received from natural sources).

Cask Testing

A primary factor in the safe transport of spent nuclear fuel is the integrity of the cask. Before a cask can be used for shipping commercial spent fuel, it must be certified by the NRC. The current standards for certification are described on page 15. The new generation of casks to be developed for NWPA shipping will be subject to certification requirements in effect at that time.

The Transportation Technology Center at Sandia National Laboratories in Albuquerque, New Mexico, conducted a series of full-scale tests on casks during the mid-70s to verify computer model projections of cask damages. These tests and the results are described below.

Crashes

Test—A tractor-trailer truck carrying a cask was crashed into a massive concrete wall at 61 mph. Another truck and cask were crashed at 84 mph.

Results—*There was no effect on the cask from the 61-mph crash. At 84 mph, the cask was deformed as predicted by calculations, but no simulated radioactive material was released. Leakage of nonradioactive liquid coolant did occur but not until the cask was lifted from the wreckage. At that point, a leak at the rate of about two drops a minute developed. This leakage stopped once the cask was placed upon another trailer. Total coolant leakage was less than a cupful and was well within the NRC regulatory limit. The use of liquid coolants in shipping casks has been discontinued.*

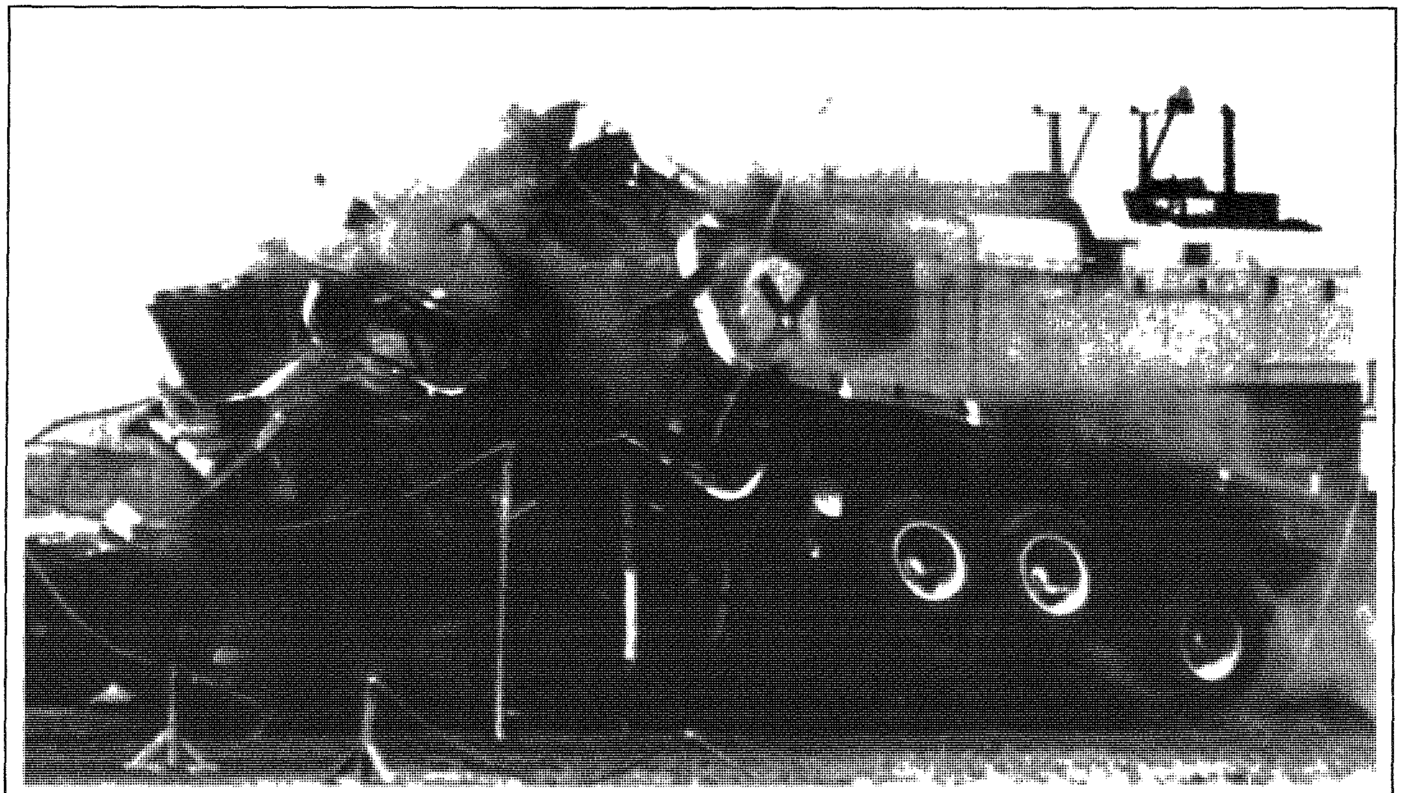
Test—A locomotive traveling at 80 mph rammed broadside a cask mounted on a truck trailer.

Results—*The cask was slightly dented—almost exactly as predicted by the computer model—while the locomotive was severely damaged. No release of simulated radioactive material occurred.*

Crash-Fire

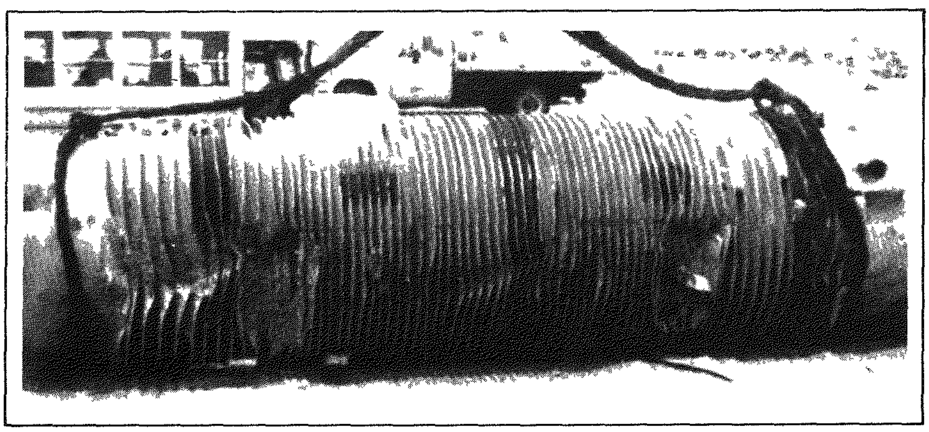
Test—A railcar carrying a cask was crashed into a massive concrete barrier at 81 mph. Then the cask and railcar were subjected to an intense, totally engulfing 125-minute jet fuel fire.

Results—*The lead shield between the inner and outer walls melted. After 100 minutes, the pressure from the molten lead (a condition corrected in casks now in service) eventually caused a small crack (0.004 of an inch wide or about the thickness of a dollar bill) in the*



Testing of shipping casks has included the ramming of a cask, mounted on a truck, by a locomotive traveling at 80 miles per hour.

outer layer of the cask through which some molten lead escaped. The amount of molten lead that escaped was not enough to lessen the cask's shielding capability, and the simulated radioactive materials remained inside the cask.



The cask was slightly dented, while the locomotive was severely damaged. No release of simulated radioactive material occurred.

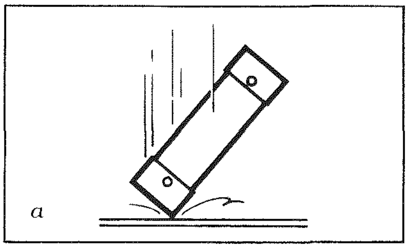
Drop

Test—A cask formerly used for shipping spent fuel from a research reactor was dropped from a helicopter, crashing into the desert floor at 235 mph.

Results—*Although the cask was buried in more than 4 feet of the hard-packed soil, some paint scratches were the only damage.*

In addition to the Sandia Laboratories' full-scale tests, the United Kingdom's Central Electricity Generating Board conducted a $2.1 million test in July 1984 in which a diesel locomotive moving at 100 mph failed to damage a nuclear waste shipping cask mounted on a railcar. The locomotive, which weighed 140 tons and was coupled to three 35-ton coaches, was wrecked in the head-on collision, but the shipping cask suffered only minor scratches, despite being hurled 200 feet.

Standards for Spent Fuel Casks



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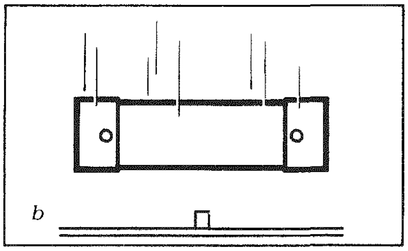

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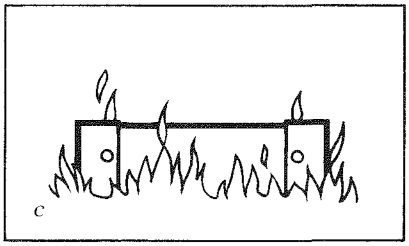

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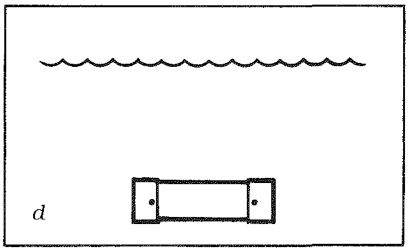


d

For certification by the NRC, a cask must be able to withstand a series of accident conditions. These conditions were developed in a National Academy of Sciences committee's recommendations on tests that would simulate damage to spent fuel casks in the most severe credible accidents. The mechanical tests (free drop and puncture), the thermal (fire) test, and the water-immersion (3 feet) test are performed in sequence to determine the cumulative effects on one package. A separate cask is subjected to the deep water-immersion (50 feet) test. Paraphrased descriptions of the regulatory tests follow.

Mechanical

a. **Free drop**—Thirty-foot drop of the spent fuel cask onto a flat, horizontal, unyielding surface* with the cask positioned so that its weakest point is struck.

b. **Puncture**—Forty-inch free drop of the cask onto a 6-inch-diameter steel bar at least 8 inches long; the bar is to strike the cask at its most vulnerable spot.

Thermal

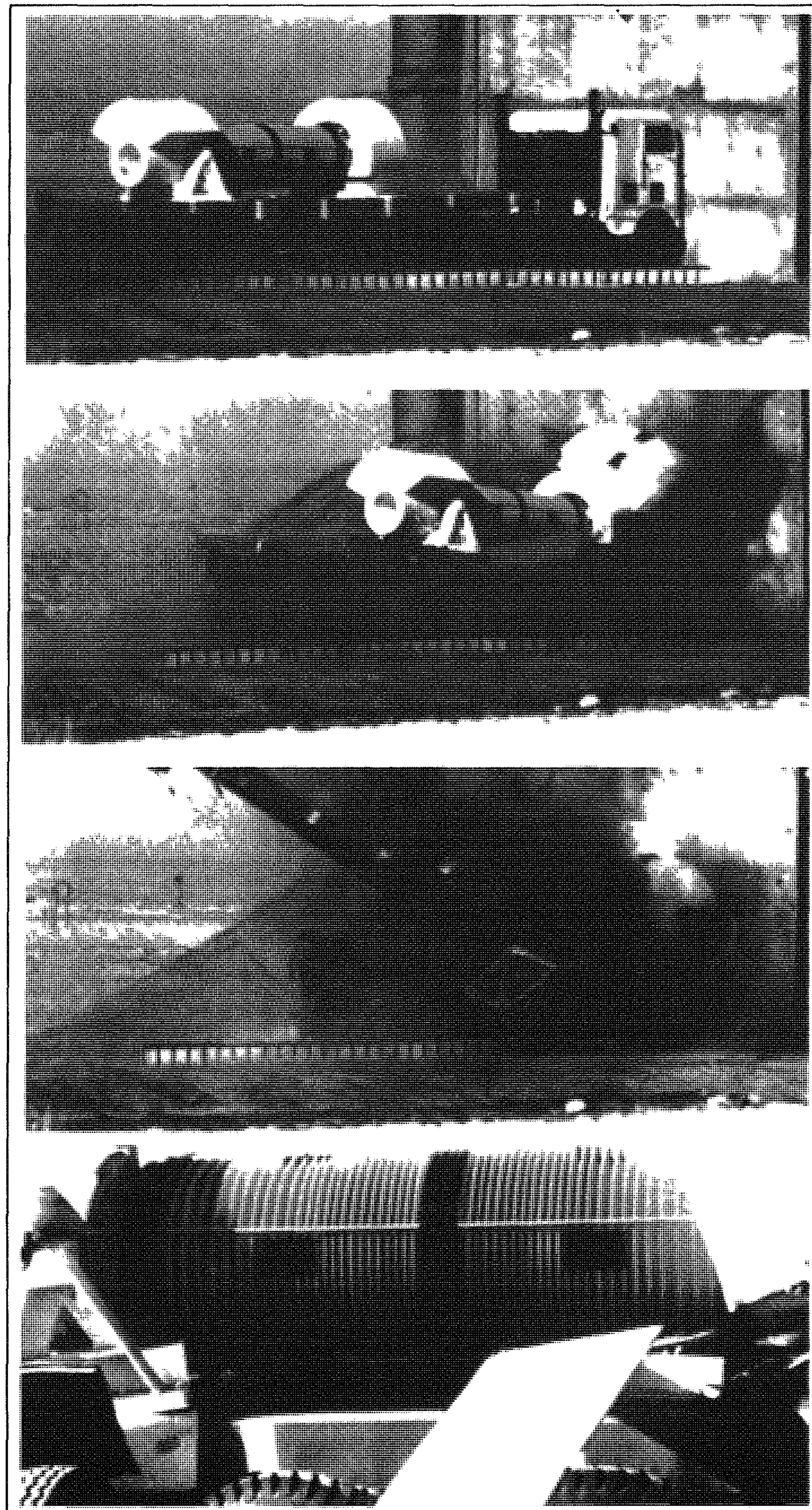
c. **Fire**—After the mechanical tests are completed, the package is totally engulfed in a fire or furnace at 1475°F for 30 minutes.

Water Immersion

d. Immersion of all packaging surfaces under at least 3 feet of water for 8 hours; immersion of entire packaging under 50 feet of water for 8 hours.

* The "unyielding surface" criteria require that the result of the impact be borne completely by the cask. Drops from heights 2.5 to 3 times greater onto normal hard surfaces would be comparable. Drop tests have been conducted at much greater heights (2000 feet) without breaching the cask containment.

Casks have also been subjected to an engulfing fire at high temperatures as part of a testing program.



A shipping cask mounted on a tractor-trailer truck survived intact an 84-miles per-hour crash of the truck into a concrete wall.

What Happens If There Is An Accident?

In more than 20 years of shipping commercial spent fuel in the United States, no accident has caused a release of radioactive material. Moreover, no deaths or serious injuries to the public or to transportation industry personnel have ever occurred as the result of the radioactive nature of any radioactive material shipment. Therefore, the following figures and scenarios used to predict exposures or damage that might result from the transportation of spent reactor fuel are based on scientific studies and tests rather than on experience.

Severe Accidents

In the event of a severe accident involving a spent fuel shipment, the cask might be somewhat damaged, but studies and tests predict that minimal, if any, radioactivity would be released. In most cases, the cask could be transported to its destination with no need for repair. A cask could remain intact indefinitely following a severe accident. A general evacuation of people from homes and businesses would not be warranted since damage and problems would involve only an area within several hundred feet of the event.

Natural Disasters

Because spent fuel casks weigh from 25 to 120 tons and have small surface areas, they are resistant to movement by high winds (i.e., hurricane or tornado). Under severe conditions, a railcar or trailer could be derailed or overturned by tornado-force winds, dumping the cask onto the ground. Tests performed by Sandia National Laboratories on tornado effects lead to this conclusion. Although such an event could result in minor external damage, release of any radioactive material would be highly unlikely.

Terrorist Attacks

Scientists at Sandia's Transportation Technology Center simulated terrorist attacks using explosive devices to determine the consequences of such an event. The detonation of an explosive on a full-scale spent fuel shipping cask indicated that less than one percent of the contents would be released.

The weight of a cask containing spent fuel should discourage most would-be hijackers from attempting to steal it by removing it from the carrying vehicle. Removal of the spent fuel from the cask would likewise be difficult since the closure plug weighs several tons. If the hijackers were able to remove the plug, they could receive a lethal dose of radiation from the exposed fuel assemblies.

DOE and other federal agencies assist state and local officials in emergency preparedness planning and training.

Emergency Preparedness

Immediate emergency response to accidents involving transport of spent fuel is similar to emergency response to accidents involving the transport of other hazardous materials. Generally, the first responders on an accident scene are local fire and police personnel. The Federal Emergency Management Agency (FEMA) suggests that those who respond first to a transportation accident involving radioactive materials should be prepared to:

- administer emergency measures to save lives and attend to any injured,
- determine if radioactive materials are present and secure information about those materials,
- contact appropriate authorities to obtain expertise for dealing with radiological materials, and
- determine the action required to prevent further damage to life or property.

Several federal and private organizations give guidance and assistance to state and local groups in emergency preparedness planning and emergency response. That assistance is outlined below:

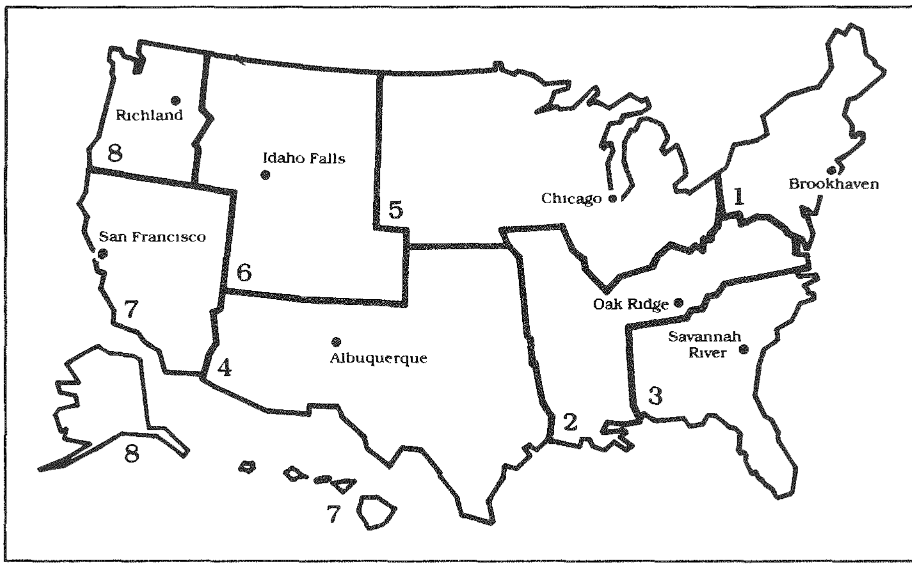
- **Federal Emergency Management Agency**—This federal agency coordinates emergency management assistance from all federal agencies to state and local governments. A FEMA document that gives guidelines for state and local emergency response and preparedness plans is available for state and local personnel with responsibility for emergency response plans. The document specifies planning objectives and related criteria for emergency response. Also, FEMA established and chairs the Federal Radiological Preparedness Coordinating Committee (FRPCC), which directs the policies of programs for assisting state and local governments in their planning and preparedness activities. The committee consists of representatives from more than a half dozen federal departments or agencies. Each federal agency in FRPCC is represented on 10 Regional Assistance Committees (RACs) located throughout the United States. The RACs review state emergency plans and observe emergency preparedness exercises to evaluate adequacy of emergency plans.

- **Department of Transportation**—The DOT has published and distributed a kit to each state to train fire, police, and ambulance personnel. This kit provides basic information on radiation and related hazards, required packaging, transportation regulations, protective measures and procedures, and planning and preparedness for transportation accidents. The DOT also furnishes to state radiation control program directors, on request, a booklet containing procedures to be followed until expert assistance arrives.

- **Department of Energy**—The DOE currently has eight regionally located offices for radiological assistance. Any of these offices can mobilize an emergency response team within 2 hours; the team can arrive at an accident scene within 8 hours. Nationwide, 28 DOE Radiological Assistance Teams (consisting of federal and contract personnel) are available. The number of personnel and type of equipment responding would depend on the nature of the emergency. Response to a terrorist attack would be by the DOE's Nuclear Emergency Search Team. In addition, the Federal Bureau of Investigation would be involved. DOE also sponsors a Radioactive Materials Hazard Awareness Workshop to assist in the training of state and local police, fire personnel, and emergency response teams from spent fuel carriers. DOE is evaluating the need for increased assistance to state and local emergency response teams in light of the expected increase in shipments under the NWPA.

- **Institute of Nuclear Power Operations**—The INPO has developed a voluntary assistance agreement among electric utility companies. That agreement defines terms and conditions under which one utility will help another in a radioactive materials transportation accident. Forty-two electric utility companies with nuclear power plants have signed the agreement.

- **Department of Defense**—The DOD Nuclear Accident Response Teams, which are formed primarily for responding to nuclear weapons accidents, are available for any situation, at DOE's request. These teams can mobilize many specially trained persons on short notice.



DOE can have emergency response teams from one of eight offices at an accident scene within 8 hours of notification to assist state and local emergency responders.

Insurance Coverage

Since 1957, the Price-Anderson Act has ensured that adequate funds would be available for third-party or public liability claims in the event of a major nuclear incident. These funds come from a combination of private insurance and government indemnity.

The maximum financial protection available per accident is $635 million (as of June 1985) for NRC licensees and $500 million for DOE contractors. If an incident results in damages exceeding the maximum limits, Congress will review the incident and take appropriate action to protect the public from the financial consequences.

Provisions in the Price-Anderson Act extend liability coverage to the transportation of radioactive materials to and from a DOE contractor or NRC-licensed facility.* The Act also covers damages suffered from terrorism, sabotage, and other illegal acts occurring while the radioactive materials are on a planned transportation route.

Since extension of the Price-Anderson Act comes before Congress in 1987, a number of bills and reports have been developed to support various modifications to the existing provisions. The DOE report to Congress recommends that the Act be extended, but with several amendments.

*Shipments of some materials with low-level radioactivity, such as uranium ore, are not covered by Price-Anderson.

Plans For An NWPA Transportation System

The development of a system to transport spent fuel from its temporary storage location at utility nuclear power plants to national repositories is one of the mandates of the NWPA. This transportation system, which is scheduled to begin operating in the late 1990s, will build on the technology already developed and the regulatory framework and industry capability now in place.

The system governing current spent fuel shipping activities provides many checks and balances that contribute to safe operation. The regulatory criteria used to develop spent fuel shipping casks and the bases for approving casks are assessed in light of existing accident data, conservative mathematical calculations, and a broad variety of test data including the physical testing of full-scale casks. These standards, supported by other regulations for packaging, labeling, handling, driver training and routing, provide the confidence that:

- the release of radioactive materials will be prevented under both normal and accident conditions;
- the shipments will be protected against theft or sabotage; and
- transportation industry personnel and the public will be protected from unacceptable levels of radiation exposure.

Finally, to reinforce protection of the public and the environment, federal and state governments have personnel as well as procedures for responding to any emergency that might arise.

The DOE recognizes, however, that conditions for shipping spent fuel at the turn of the century could differ significantly from the conditions that prevail today. For example, the number of future shipments to repositories will represent a substantial increase over the number of current shipments. This increase necessitates a careful review of existing procedures to determine if changes are required for continued assurance of safety. Additionally, the fuel to be shipped to the repositories will have been aged (out of the reactor) for a minimum of 5 years. Since casks being used today are designed to accommodate fuel that has been aged for only about a half year, development of more efficient "new-generation" cask designs that can measurably increase the capacity is indicated. The program that the DOE is conducting will develop a transportation system that embodies such technical and procedural changes.

A key ingredient of the DOE program is to encourage participation in system planning by state and tribal representatives, industry and the utilities, and the interested public. Information will be provided by printed and visual material, including booklets such as this, and through workshops and meetings. Discussion of transportation issues will be encouraged in an attempt to develop consensus approaches to issue resolution. The NWPA has identified nuclear waste as a problem of national concern. Implementation of the program to provide a safe and equitable solution must be a cooperative effort of all interested parties.

Glossary

Canister—metal container for spent fuel assemblies, consolidated spent fuel rods, nuclear waste, etc.

Cask—large metal container used to transport either spent fuel assemblies, canisters of consolidated fuel rods, or nuclear waste.

Consolidation—the close grouping of fuel rods after their removal from a spent fuel assembly; a procedure that reduces the volume of radioactive materials to be transported.

Dedicated train—a train designated for the transport of a particular commodity between fixed origin and destination points.

Dose—quantity of radiation absorbed by the body.

Fuel assembly—bundle of fuel rods used in a reactor.

MRS—monitored retrievable storage; an above-ground storage system being studied by DOE as an element of the repository system.

Millirem—one-thousandth of a rem.

Nuclear power plant—a nuclear reactor or reactors together with all structures, systems, and components necessary for safety and for the production of power.

Radioactivity—the spontaneous emission of radiation from the nucleus of an atom. Radioisotopes of elements lose particles and energy through the process of radioactive decay.

Reactor—a device involving a chain reaction using atomic particles.

Rem—a measurement of the effects a dose of ionizing radiation would have on human tissue.

Repository—any system licensed by the Nuclear Regulatory Commission that is intended to be used for the permanent deep geological disposal of high-level radioactive waste and spent fuel.

Shipment mile—the number of miles a single shipment of spent fuel (one or more casks per shipment) travels from origin to destination.

Spent fuel—nuclear fuel that has been removed from a reactor after being used to produce electric power.

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Appendix I

CASK SAR REVISIONS

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CASK SAR REVISIONS

During the campaign, there were several revisions to the cask's SAR submitted to NRC. The descriptions below summarize the reason for each proposed request for a revision to the licensing basis for the fuel shipping program.

On November 10, 1986, GPU Nuclear requested approval from the NRC TMI-2 site office of an alternative acceptance criterion for dewatering of fuel canisters and a reduction in the amount of catalysts required to be exposed following dewatering.[1] Canister related TMI-2 site safety evaluations were approved earlier by the NRC in two documents: the Defueling Canisters Technical Evaluation Report (Canister TER) and the Canister Handling and Preparation for Shipment Safety Evaluation Report (CHAPS SER).

However, GPU Nuclear was experiencing difficulty with the dewatering acceptance criterion in the CHAPS SER which required, "Weights taken before and after the canister is dewatered will be used to determine the actual volume of water removed. If this amount exceeds 50% of the empty canister free volume, then the canister is considered to be sufficiently dewatered and can be shipped."

Defueling operations had shown that when a significant amount of core structural materials were loaded into a fuel canister, rather than fuel pellets, there was correspondingly less void volume in a canister. That is, since steel is less dense than uranium, for the same weight of material in a canister, there would be more canister internal volume taken up by the steel than the uranium. The relative decrease in void volume meant less water was present in a flooded canister such that during the dewatering process not as much water could be removed from canisters containing structural materials as from canisters containing relatively more uranium materials (i.e., more by weight).

The November 10, 1986 safety evaluation submitted by GPU Nuclear to NRC committed to performing additional operational steps in canister dewatering and calculations of gas pressure based on results from gas generation monitoring of each canister prior to shipment. These steps were considered necessary to ensure that adequate safety margins would exist using the revised acceptance criterion. The proposed dewatering acceptance criterion was expressed as weight of water removed as a function of the weight of a canister's payload.

On December 30, 1986, GPU Nuclear submitted additional information to NRC to support the November request.[2] The submittal included a bounding calculation for all fuel canisters and proposed that achieving a 25 percent void volume in a fuel canister by dewatering would be acceptable and not impact the safety evaluation in the cask SAR. In a meeting held on January 7, 1987 at TMI, representatives from GPU Nuclear, NRC, and EG&G Idaho met to discuss GPU Nuclear's request for a revised dewatering criterion and NRC's requirements for granting approval.

The requirement agreed to at the meeting was reflected in an approval by NRC on January 7, 1987 for a reduced canister void volume.[3] NRC required GPU Nuclear to expand monitoring of radiolytic gas generation in canisters. The NRC's evaluation of the safety of the revised criterion was based in part on the results obtained from monitoring canisters at TMI-2 for several days prior to shipment. In the TMI-2 measurements, gas appearance rates were all very low and showed one of two situations, either the presence of both hydrogen and oxygen in very small concentrations or an excess of hydrogen and lack of oxygen due to oxygen scavenging. In cases of oxygen scavenging, the hydrogen appearance rate was less than ten percent of the maximum probable rate used in the safety evaluations in the cask's SAR.

NRC required monitoring of gas generation in canisters over a duration of about six weeks. Since such a duration could have impacted on–going fuel shipments from TMI-2, NRC allowed the measurements to be made at INEL prior to reflooding the canisters for storage in the pool. From each shipment to INEL, one canister was to be gas sampled shortly after arrival and again about six weeks later. This monitoring program was required until sufficient data became available to demonstrate the safety of the revised dewatering criterion but as stated in NRC's approval letter, "...no further licensing action is required as a result of this issue." There was not a revision to the cask's SAR submitted for this change in the licensing basis.

GPU Nuclear requested an amendment to the CoC in a licensing submittal made to the NRC TCB on December 12, 1986.[4] The request was to permit a change to the closure bolt torque required for fuel canister upper heads. The range of torque approved by NRC in the cask's SAR was 50-60 ft-lbs. GPU Nuclear requested a change to 40-60 ft-lbs and approval to ship a canister with a bolt which failed to properly seat but was torqued between 40-60 ft-lbs. NRC TCB approved the request for a change in torque range on a temporary basis on December 13, 1986 but did not approve shipment of the canister with only seven of the eight bolts effective. A subsequent permanent revision to the cask's SAR was not pursued and the acceptable range for bolt torque on fuel canisters remained 50-60 ft-lbs. The canister with the improperly seated bolt was repaired such that all eight bolts were effective prior to shipment.

On January 8, 1987, NuPac responded to a request from EG&G Idaho and submitted a letter to NRC TCB asking for a temporary modification to the CoC to allow for shipment of the cask with a tarp covering the entire package. The purpose of the tarp was to maintain cleanliness and prevent ice buildup during transport. The tarp had been in use but the need for a specific analysis of the safety significance of a tarp was not made known to NuPac until January 7, 1987. The need for analysis was made known to GPU Nuclear and EG&G Idaho at the meeting with NRC on dewatering void volumes for canisters discussed above. The need was based on an NRC Information Notice issued in June 1985.[5]

The NuPac request for use of a tarp was approved by NRC on a temporary basis on January 9, 1987. NuPac submitted Revision 4 of the cask's SAR on April 29, 1987 incorporating the tarp into the SAR. NRC issued Revision 2 of the cask's CoC on May 15, 1987 approving the change.

On June 12, 1987 and with corrected pages again on June 26, 1987, NuPac submitted Revision 5 to the cask's SAR to request approval of: (1) transport of an empty cask as a low specific activity (LSA) package, (2) optional design features to improve cask fabrication, and (3) minor corrections to the drawing of the cask in the SAR. The ability to ship an empty cask as an LSA package was requested to allow transport without extensive decontamination of the cask's internal surfaces or leakage rate testing as required for a cask containing significant quantities of radioactivity. The request for changes in design features of the cask were the result of fabrication of a third cask to expedite the fuel shipments to the INEL. The principal design feature change requested by NuPac was to add an optional drain location to the outer cask's body. The drain was plugged in fabrication of the third cask but is now available for potential future uses of the cask requiring underwater loading. NRC issued Revision 3 of the cask's CoC on July 17, 1987 approving the changes.

On September 22, 1987 and with corrected pages again on October 2, 1987, NuPac submitted Revision 6 of the cask's SAR to allow for thicker skin on, and a center drain tube through, the internal impact limiters used in the ICV to protect canisters axially in the event of end drop accidents during transport. The thicker skin (0.008-inch) was to preclude damage to the skins under normal handling operations as had been experienced with the original thickness skins (0.004-inch). The central drain tube was incorporated into the lower internal impact limiters to allow for removal of water without the need for removal of the limiters. NRC issued Revision 4 of the cask's CoC on October 28, 1987 approving the changes.

This point in time is the end of the pattern of submitting an SAR revision followed by NRC approval and CoC revision. The following discussion describes circumstances leading to each CoC revision.

The next revision to the CoC was based on a submittal made by EG&G Idaho to the NRC TCB on November 23, 1987. EG&G Idaho advised NRC that testing to develop another shipping package (TRUPACT-II) had investigated the performance of some neoprene seal compounds for sealing performance at cold temperatures.[6] To ensure that the seals in the 125-B cask met the low temperature performance requirements, EG&G Idaho submitted a summary of the low temperature seal test program that determined a specific neoprene compound which met all requirements. EG&G Idaho committed to placing a more detailed specification for the particular seal material in the next revision of the cask's SAR. NRC did not wait for the cask's SAR to be revised before acting. NRC issued Revision 5 of the cask's CoC on December 8, 1988 requiring the use of the specific neoprene compound identified in EG&G Idaho's submittal.

On January 16, 1989, NuPac submitted Revision 10 of the cask's SAR (Revisions 7, 8 and 9 are discussed below). Revision 10 presented the results of the cold temperature testing of seal compounds and incorporated a detailed specification for an acceptable neoprene compound throughout the SAR. The submittal also included a revision to the gas generation monitoring performed at TMI-2 and a minor modification to the plug used to seal canisters. The gas generation monitoring change committed GPU Nuclear to about two weeks of monitoring for each canister prior to shipment and noted the results of INEL's monitoring program which showed that gas production decreases in a canister with time. NRC issued Revision 6 to the cask's CoC on February 28, 1989 approving the changes.

To obtain Revision 7 of the CoC required three SAR revisions. On October 12, 1987, NuPac submitted Revision 7 of the cask's SAR to allow use of cadmium plated bolts in the cask's lids and overpacks for improved operations during bolt installation (lower torque requirements). The submittal also corrected inconsistencies in the cask's SAR drawing. NRC issued a set of questions to NuPac on the proposed revision in December 1987.

On February 24, 1988, NuPac responded to NRC's questions and submitted Revision 8 to the cask's SAR. Revision 8 changed the SAR to specify use of only cadmium plated bolts and torque values appropriate for the plated bolts (thereby eliminating an option for use of plated or unplated bolts and a possible source of confusion during operations). NRC issued a set of questions to NuPac on the proposed revision in July 1988.

On November 28, 1988, NuPac responded to NRC's questions and submitted Revision 9 to the cask's SAR. Revision 9 included the reperformance of all of the applicable bolting analyses to address the combination of pretorque and torque coefficient values which result in a worst-case for the cask. NRC issued Revision 7 to the cask's CoC on June 14, 1989 approving the changes.

On September 11, 1989, NuPac submitted Revision 11 to the cask's SAR proposing a change to the size of fuel particles allowed in filter canisters. The screen upstream of the filter canister limited particles to 850 microns or less but clogged often which imposed significant operational restrictions for GPU Nuclear. The submittal provided a revised criticality evaluation for a filter canister showing that safety would be maintained if more realistic assumptions were made regarding the fuel debris composition in the analyses. The revised calculations allowed credit for a core average initial enrichment and limited buildup of non-soluble fission products and fissile plutonium (i.e., burnup credit). Review of this submittal by NRC was not completed before the end of the defueling of the reactor and NuPac withdrew Revision 11 on March 8, 1990.

The final activity with respect to cask licensing was a reconsolidation of the SAR submitted to NRC on April 6, 1991 with corrected pages on April 9 and 15, 1991. NRC's review of the consolidated SAR resulted in reapproval of the NuPac 125-B cask for another five years and issuance of Revision 8 of the CoC on May 6, 1991.

References

1. F. R. Standerfer ltr to W. D. Travers, *Three Mile Island Nuclear Station, Unit 2 (TMI-2), Operating License No. DPR-73, Docket No. 50–230, Canister Dewatering*, 4410-86-L-0193, Document ID 0062P, November 10, 1986.

2. F. R. Standerfer ltr to W. D. Travers, *Three Mile Island Nuclear Station, Unit 2 (TMI-2), Operating License No. DPR-73, Docket No. 50-230, Canister Dewatering*, 4410-86-L-0220, Document ID 0149P, December 30, 1986.

3. W. D. Travers ltr to F. R. Standerfer, *Reduced Defueling Canister Void Volume*, NRC/TMI 87-003, January 7, 1987.

4. F. R. Standerfer ltr to C. E. MacDonald, *Three Mile Island Nuclear Station, Unit 2 (TMI-2), Operating License No. DPR-73, Docket No. 50-230, Request for Amendment of Certificate of Compliance No. 9200 For the NuPac 125-B Shipping Cask*, 4410-86-L-0212, Document ID 0143P, December 12, 1986.

5. U.S. Nuclear Regulatory Commission, *IE Information Notice No. 85-46: Clarification of Several Aspects of Removable Surface Contamination Limits for Transport Packages*, SSINS No. 6835, Office of Inspection and Enforcement, Washington, DC, June 10, 1986.

6. W. A. Franz ltr to C. E. MacDonald, *Docket 71-9200 – Seal Performance Evaluation*, WAF-49-88, November 23, 1988.

Appendix J

TMI-2 Core Shipping Information

Cask Ship No.	Rail Ship No Cask No. Rail Car No Can. Payload	Cask Leak Tests	Assbl/ Maint	Cover Gas	Cask Shipment: Movement (Date)	Cask Shipment: Duration (Days)	Total Days	Inspection & Maintenance (Date)	Max Rad Level at Contact (mR/h)	Maximum Internal Contamination (dpm/100cm2)	Water in ICV (gal)	TMI MNCRs	INEL NCRs	Comments
001	Ship# 001 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 2536	ICV OCV	Maint Maint	He He	from TMI 07/20/86 to CFA 07/24/86 to TAN 07/25/86 to CFA 07/30/86 from INEL 08/02/86 at TMI 08/12/86	to INEL 4 at CFA 1 at TAN 5 at CFA 3 to TMI 10	TMI 90 INEL 9 Ship 14 Cycle 113	Car Insp 08/04/86 Cask Maint. 07/29/86	Leave TMI 2.5 Arrive INEL 2.5 Empty to TMI <0.1	Beta-Gamma 97,400 ICV Posi. 2 Decon No	1.25	None	None	Cask delivered to TMI 4/21/86 by NuPac Cask displayed at Blackfoot, ID
002	Ship# 002 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 8183	ICV OCV	Maint Maint	He He	from TMI 08/31/86 to CFA 09/04/86 to TAN 09/11/86 to CFA 09/23/86 from INEL 09/27/86 at TMI 10/09/86	to INEL 4 at CFA 7 at TAN 12 at CFA 4 to TMI 12	TMI 166 INEL 23 Ship 16 Cycle 205	Car Insp. 09/30/86 Cask Maint. 09/18/86	Leave TMI 1.0 Arrive INEL 4.0 Empty to TMI <0.1	Beta-Gamma 44,000 ICV Posi. 4 Decon No	0.33	None	TM-4851	Cask delivered to TMI 3/18/86 by NuPac. OCV lid bolt #9 rounded/replaced-railcar, 16 brakeshoes replaced, wheel tread excess wear
003	Ship# 002 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 6204	ICV OCV	Maint Maint	He He	from TMI 08/31/86 to CFA 09/04/86 to TAN 09/05/86 to CFA 09/11/86 from INEL 09/13/86 at TMI 09/26/86	to INEL 4 at CFA 1 at TAN 6 at CFA 2 to TMI 13	TMI 19 INEL 9 Ship 17 Cycle 45	Car Insp 09/17/86 Cask Maint. None	Leave TMI <0.1 Arrive INEL 0.7 Empty to TMI <0.1	Beta-Gamma 306,420 ICV Posi. 3 Decon Yes	0.50	None	TM-4849	One skid pin lanyard replaced; trunnion keeper plates fixed, lanyard replaced and pin straightened; ICV Pos. 3 deconed to 32,000 dpm beta-gamma
004	Ship# 003 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 9589	ICV OCV	Maint Maint	He He	from TMI 12/14/86 to CFA 12/17/86 to TAN 12/30/86 to CFA 01/08/87 from INEL 01/10/87 at TMI 01/23/87	to INEL 3 at CFA 13 at TAN 9 at CFA 2 to TMI 13	TMI 79 INEL 24 Ship 16 Cycle 119	Car Insp. 01/13/87 Cask Maint. None	Leave TMI 0.4 Arrive INEL 1.6 Empty to TMI <0.2	Beta-Gamma 14,000,000 ICV Posi. 4 Decon Yes	0.60	None	TM-4878 TM-4881 TM-4882	Cask disassembled to torque D-106 bolt; UOR EGG-86-29 - no Guards; Damage skid tiedown at TAN
005	Ship# 003 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 9850	ICV OCV	Maint Maint	He He	from TMI 12/14/86 to CFA 12/17/86 to TAN 12/18/86 to CFA 12/22/86 from INEL 12/23/86 at TMI 12/30/86	to INEL 3 at CFA 1 at TAN 4 at CFA 1 to TMI 7	TMI 66 INEL 6 Ship 10 Cycle 82	Car Insp. None Cask Maint. None	Leave TMI 1.8 Arrive INEL 5.0 Empty to TMI 0.4	Beta-Gamma 9,000,000 ICV Posi. 4 Decon Yes	0.60	None	TM-4875	UOR EGG-86-29 - no Guards
006	Ship# 004 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 9458	ICV OCV	Maint Maint	He He	from TMI 01/11/87 to CFA 01/14/87 to TAN 01/17/87 to CFA 01/21/87 from INEL 01/24/87 at TMI 02/04/87	to INEL 3 at CFA 3 at TAN 4 at CFA 3 to TMI 11	TMI 12 INEL 10 Ship 14 Cycle 36	Car Insp. 01/27/87 Cask Maint. 01/20/87	Leave TMI 0.86 Arrive INEL 1.5 Empty to TMI 0 1	Beta-Gamma >500,000 ICV Posi. 2 Decon Yes	1.70	None	None	Gas sample-D-148. Rail car tilted about 2 inches (hard lub disk)
007	Ship# 005 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 8796	ICV OCV	Maint Maint	He He	from TMI 02/01/87 to CFA 02/04/87 to TAN 02/06/87 to CFA 02/12/87 from INEL 02/14/87 at TMI 02/26/87	to INEL 3 at CFA 2 at TAN 6 at CFA 2 to TMI 12	TMI 9 INEL 10 Ship 15 Cycle 34	Car Insp 02/16/87 Cask Maint None	Leave TMI 0.6 Arrive INEL 1.0 Empty to TMI 0 1	Beta-Gamma 960,680 ICV Posi. 5 Decon Yes	0.40	None	None	Gas sample-D-145.
008	Ship# 006 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 8903	ICV OCV	Maint Maint	He He	from TMI 02/15/87 to CFA 02/18/87 to TAN 02/20/87 to CFA 02/25/87 from INEL 02/28/87 at TMI 03/07/87	to INEL 3 at CFA 2 at TAN 5 at CFA 3 to TMI 7	TMI 11 INEL 10 Ship 10 Cycle 31	Car Insp None Cask Maint. None	Leave TMI 1 5 Arrive INEL 4.0 Empty to TMI 0 1	Beta-Gamma 1,159,630 ICV Posi C Decon Yes	0.75	None	TM-4900	Gas sample-D-180 Several ICV bolts flaredout, and several OCV bolts beginning to round off. Scraching on bottom of cask about 3 ft long. Quick release pins on ratchet bender broken
009	Ship# 007 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 9358	ICV OCV	Maint Maint	He He	from TMI 03/22/87 to CFA 03/26/87 to TAN 04/03/87 to CFA 04/09/87 from INEL 04/11/87 at TMI 04/20/87	to INEL 4 at CFA 8 a+ TAN 6 at CFA 2 to TMI 9	TMI 24 INEL 16 Ship 13 Cycle 53	Car Insp. None Cask Maint 04/08/87	Leave TMI 2 5 Arrive INEL 3 0 Empty to TMI 0 5	Beta-Gamma 1,814,720 ICV Posi 4 Decon Yes	0.59	None	TM-4912 TM-4913 IR-12355	Train delayed by minor automobile accident and a train derailed by high winds. Gas sample-D-162 Two skids lift cap welds had cracks repaired Tarp repaired Lower radius of upper trunnions scratched-repaired

Cask Ship No.	Rail Ship No. / Cask No. / Rail Car No. / Can. Payload	Cask Leak Tests (Assbl/Maint, Cover Gas)	Cask Shipment: Movement	(Date)	Duration (Days)	Total Days	Inspection & Maintenance (Date)	Max. Rad. Level at Contact (mR/h)	Maximum Internal Contamination (dpm/100cm2)	Water in ICV (gal)	TMI MNCRs	INEL NCRs	Comments
010	Ship# 007 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 10490	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	03/22/87 03/26/87 03/27/87 04/02/87 04/04/87 04/16/87	to INEL 4 at CFA 1 at TAN 6 at CFA 2 to TMI 12	TMI 15 INEL 9 Ship 16 Cycle 40	Car Insp. None Cask Maint. None	Leave TMI 2.0 Arrive INEL 2.0 Empty to TMI 0.2	Beta-Gamma 218,820 ICV 5 Posi. Decon No	0.75	78-87	IR-87-01	Train delayed by minor automobile accident and a train derailed by high winds. Gas Sample-D-188.Deficiencies identified for shipment 008 were not corrected at TMI. INEL replaced four lanyards and 2 quick release pins (3 pins need inspection at TMI - loose). Tarp repaired.
011	Ship# 008 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 6028	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	06/21/87 06/25/87 06/26/87 06/30/87 07/03/87 07/10/87	to INEL 4 at CFA 1 at TAN 4 at CFA 3 to TMI 7	TMI 62 INEL 8 Ship 11 Cycle 81	Car Insp. None Cask Maint. None	Leave TMI 0.9 Arrive INEL 3.0 Empty to TMI 0.1	Beta-Gamma 76,060 ICV 1 Posi. Decon No	0.86	None	None	Annual track maintenance caused slight transport to INEL delays.
012	Ship# 008 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 7688	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	06/21/87 06/25/87 07/01/87 07/07/87 07/09/87 07/15/87	to INEL 4 at CFA 6 at TAN 6 at CFA 2 to TMI 6	TMI 70 INEL 14 Ship 10 Cycle 94	Car Insp. None Cask Maint. None	Leave TMI 2.5 Arrive INEL 2.0 Empty to TMI <0.1	Beta-Gamma 79,150 ICV 4 Posi. Decon No	0.75	None	TM-4936	Gas sample-D-207. Annual track maintenance caused slight transport to INEL delays. Canister grapple cable broke. Two skid trunnion lift caps had cracks repaired before shipping to INEL.
013	Ship# 009 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 5477	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	07/26/87 07/30/87 07/31/87 08/04/87 08/08/87 08/19/87	to INEL 4 at CFA 1 at TAN 4 at CFA 4 to TMI 11	TMI 16 INEL 9 Ship 15 Cycle 40	Car Insp. 08/11/87 Cask Maint. 08/08/87	Leave TMI 2.0 Arrive INEL 6.0 Empty to TMI <0.1	Beta-Gamma 93,210 ICV 3 Posi. Decon No	0.69	None	TM-4943	Gas sample-D-267. Shield plug came apart.
014	Ship# 009 Cask# D02-IT Car# IDOX-101 Can P. (lbs) 6703	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	07/26/87 07/30/87 08/05/87 08/12/87 08/15/87 08/26/87	to INEL 4 at CFA 6 at TAN 7 at CFA 3 to TMI 11	TMI 11 INEL 16 Ship 15 Cycle 42	Car Insp. 08/17/87 Cask Maint. D8/11/87	Leave TMI 2.2 Arrive INEL 12.0 Empty to TMI <0.5	Beta-Gamma 650,000 ICV 3 Posi. Decon Yes	0.78	None	TM-4947	Shield plug came apart. Two canisters(D-223,D-227) could not fill water. Neutron reading was 15 mR/h at cask surface(due to neutron source in D-122).
015	Ship# 010 Cask# 001-IT Car# IDOX-100 Can P. (lbs) 6609	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	09/13/87 09/17/87 09/18/87 09/23/87 09/26/87 10/03/87	to INEL 4 at CFA 1 at TAN 5 at CFA 3 to TMI 7	TMI 25 INEL 9 Ship 11 Cycle 45	Car Insp. None Cask Maint. * 09/18/87	Leave TMI 3.6 Arrive INEL 4.5 Empty to TMI 1.5	Beta-Gamma 35,000 ICV C Posi. Decon No	0.65	None	TM-4953	* Annual inspection of impact limiters at TMI-LJB-8I-87 -3 bolts could not be hand threaded into cask. They were reworked. -Lower impact limiter in cask port No.3 could not be re-inserted, swiched with port No.2. -Replaced lanyard / dirty rad placard.
016	Ship# 010 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 6573	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	09/13/87 09/17/87 09/24/87 09/28/87 10/03/87 10/10/87	to INEL 4 at CFA 7 at TAN 4 at CFA 5 to TMI 7	TMI 18 INEL 16 Ship 11 Cycle 45	Car Insp. None Cask Maint. * 09/18/87	Leave TMI 3.2 Arrive INEL 3.5 Empty to TMI 1.0	Beta-Gamma 33,330 ICV 3 Posi. Decon No	0.44	None	None	* Annual inspection of impact limiters at TMI-LJB-8I-87 -Gas sampling canister -- K-501. -Rad placard spring latch replaced. -Several lid bolts need to be checked at TMI.
017	Ship# 011 Cask# D01-IT Car# IDOX-100 Can P. (lbs) 6955	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	10/25/87 10/29/87 10/29/87 11/03/87 11/07/87 11/15/87	to INEL 4 at CFA 0 at TAN 5 at CFA 4 to TMI 8	TMI 22 INEL 9 Ship 12 Cycle 43	Car Insp. None Cask Maint. None	Leave TMI 2.0 Arrive INEL 3.0 Empty to TMI 0.2	Beta-Gamma 96,000 ICV 3 Posi. Decon No	0.27	None	None	Tarp repaired.
018	Ship# 011 Cask# 002-IT Car# IDOX-101 Can P. (lbs) 7871	ICV Maint He OCV Maint He	from TMI to CFA to TAN to CFA from INEL at TMI	10/25/87 10/29/87 11/03/87 11/12/87 11/14/87 11/24/87	to INEL 4 at CFA 5 at TAN 9 at CFA 2 to TMI 10	TMI 15 INEL 16 Ship 14 Cycle 45	Car Insp. * 11/16/87 Cask Maint. None	Leave TMI 2.0 Arrive INEL 2.0 Empty to TMI 0 2	Beta-Gamma 35,040 ICV 3 Posi. Decon No	0.33	None	None	Tarp repaired. * Inner lid bolt hols chamfer/bolts reworked (TRA). 12 brake shoes span bolster wear ring repaired. Gas sampling canister -- D-288. (Didn't sample)

Cask Ship No.	Rail Ship No / Cask No. / Rail Car No. / Can. Payload		Cask Leak Tests	Assbl/ Maint	Cover Gas	Cask Shipment Movement	(Date)	Duration (Days)		Total Days		Inspection & Maintenance (Date)	Max. Rad. Level at Contact (mR/h)		Maximum Internal Contamination (dpm/100cm2)		Water in ICV (gal)	TMI MNCRs	INEL NCRs	Comments
						from TMI	11/15/87					Car Insp.	Leave	2.0	Beta-	44,460				1st shipment by No.003 cask.
	Ship#	012	ICV	Maint	He	to CFA	11/19/87	to INEL	4	TMI	22	11/30/87	TMI		Gamma					Gas sampling canister -- D-298. (Didn't sample)
019	Cask#	003-3215				to TAN	11/19/87	at CFA	0	INEL	9		Arrive	2.0	ICV	C	0.57	None	TM-	Machined overpack bolt washers, tack welded skid/rail-
	Car#	NPIX-100				to CFA	11/24/87	at TAN	5	Ship	14	Cask Maint.	INEL		Posi.				4961	car tie down pin handles, and ground down legs to remove
	Can P.		OCV	Maint	He	from INEL	11/28/87	at CFA	4	Cycle	45	None	Empty	0.1	Decon	No				cask/skid interference.
	(lbs)	8118				at TMI	12/08/87	to TMI	10				to TMI							Cask No.003 arrived at TMI on 10/24/87 from NUPAC.
						from TMI	12/20/87					Car Insp.	Leave	2.2	Beta-	19,000				Gas sampling canister -- D-242. (Didn't sample)
	Ship#	013	ICV	Maint	He	to CFA	12/24/87	to INEL	4	TMI	26	None	TMI		Gamma					
020	Cask#	002-1T				to TAN	12/28/87	at CFA	4	INEL	9		Arrive	4.0	ICV	1	0.16	None	None	
	Car#	IDOX-101				to CFA	12/31/87	at TAN	4	Ship	11	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	01/02/88	at CFA	1	Cycle	46	None	Empty	0.2	Decon	No				
	(lbs)	7721				at TMI	01/09/88	to TMI	7				to TMI							
						from TMI	12/20/87					Car Insp.	Leave	2.0	Beta-	34,160				Ground down legs to remove cask/skid interference.
	Ship#	013	ICV	Maint	He	to CFA	12/24/87	to INEL	4	TMI	12	01/11/88	TMI		Gamma					Gas sampling canister -- D-238. (Didn't sample)
021	Cask#	003-3215				to TAN	01/04/88	at CFA	11	INEL	16		Arrive	3.0	ICV	2	0.16	None	TM-	
	Car#	NPIX-100				to CFA	01/07/88	at TAN	3	Ship	15	Cask Maint.	INEL		Posi.				4962	
	Can P.		OCV	Maint	He	from INEL	01/09/88	at CFA	2	Cycle	43	None	Empty	0.1	Decon	No				
	(lbs)	7648				at TMI	01/18/88	to TMI	11				to TMI							
						from TMI	12/20/87					Car Insp.	Leave	4.0	Beta-	8,060				Inner lid bolt holes chamfer/bolts reworked (TRA).
	Ship#	013	ICV	Maint	He	to CFA	12/24/87	to INEL	4	TMI	35	01/18/88	TMI		Gamma					Tack welded skid/railcar tie down pin handles.
022	Cask#	001-1T				to TAN	01/07/88	at CFA	14	INEL	23		Arrive	4.0	ICV	5	0.23	None	TM-	Added overpack bolt guides.
	Car#	IDOX-100				to CFA	01/13/88	at TAN	6	Ship	15	Cask Maint.	INEL		Posi.				4963	
	Can P.		OCV	Maint	He	from INEL	01/16/88	at CFA	3	Cycle	73	None	Empty	0.2	Decon	No				
	(lbs)	7777				at TMI	01/27/88	to TMI	11				to TMI							
						from TMI	02/07/88					Car Insp.	Leave	2.0	Beta-	194,180				The lower impact limiter in the center hole damaged.
	Ship#	014	ICV	Maint	He	to CFA	02/11/88	to INEL	4	TMI	11	None	TMI		Gamma					The honey comb material has come loose from the lower
023	Cask#	001-1T				to TAN	02/16/88	at CFA	5	INEL	9		Arrive	3.0	ICV	3	0.35	None	None	plate.
	Car#	IDOX-100				to CFA	02/18/88	at TAN	2	Ship	11	Cask Maint.	INEL		Posi.					The roll of duct tape was crushed and stuck to the
	Can P.		OCV	Maint	He	from INEL	02/20/88	at CFA	2	Cycle	31	02/17/88	Empty	0.2	Decon	No				bottom of canister D-256.
	(lbs)	7269				at TMI	02/27/88	to TMI	7				to TMI							Simi-annual PM lower trunnions and Micarta inserts.
						from TMI	02/07/88					Car Insp.	Leave	2.0	Beta-	60,100				Simi-annual PM lower trunnions and Micarta inserts.
	Ship#	014	ICV	Maint	He	to CFA	02/11/88	to INEL	4	TMI	18	None	TMI		Gamma					
024	Cask#	003-3215				to TAN	02/11/88	at CFA	0	INEL	6		Arrive	2.0	ICV	3	0.15	None	None	
	Car#	NPIX-100				to CFA	02/16/88	at TAN	5	Ship	11	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	02/17/88	at CFA	1	Cycle	35	02/12/88	Empty	0.1	Decon	No				
	(lbs)	6529				at TMI	02/24/88	to TMI	7				to TMI							
						from TMI	02/07/88					Car Insp.	Leave	1.5	Beta-	16,000				Trap tie-downs damaged/replaced. Paper towel under
	Ship#	014	ICV	Maint	He	to CFA	02/11/88	to INEL	4	TMI	29	02/29/88	TMI		Gamma					por No.1 impact limiter. Simi-annual PM lower trunnions
025	Cask#	002-1T				to TAN	02/18/88	at CFA	7	INEL	16		Arrive	2.2	ICV	3	0.59	None	None	and Micarta inserts. Railcar-temp replace R1 & R2 wheel
	Car#	IDOX-101				to CFA	02/22/88	at TAN	4	Ship	13	Cask Maint.	INEL		Posi.					;L3 brake shoe replaced; -"A" end,air hose S hook
	Can P.		OCV	Maint	He	from INEL	02/27/88	at CFA	5	Cycle	58	02/19/88	Empty	0.2	Decon	No				missing/replaced; -Span Bolster center plate had ~8"
	(lbs)	7693				at TMI	03/07/88	to TMI	9				to TMI							crack/rewelded; Shim added to side bearing at R3 & R4;
						from TMI	04/10/88					Car Insp.	Leave	<0.1	Beta-	109,240				Gouges inside the right and left skid supports legs.
	Ship#	015	ICV	Maint	He	to CFA	04/14/88	to INEL	4	TMI	46	05/02/88	TMI		Gamma					Wedge plate at cask shear plate & skid lifted when
026	Cask#	003-3215				to TAN	04/25/88	at CFA	11	INEL	16		Arrive	0.1	ICV	4	0.61	None	TM-	ratchet binder pushed the plate into position.
	Car#	NPIX-100				to CFA	04/28/88	at TAN	3	Ship	13	Cask Maint.	INEL		Posi.				4978	12 scratches ~1/32" on Trunion/Micras Inserts.
	Can P.		OCV	Maint	He	from INEL	04/30/88	at CFA	2	Cycle	75	None	Empty	<0.1	Decon	No				
	(lbs)	912				at TMI	05/09/88	to TMI	9				to TMI							
						from TMI	04/10/88					Car Insp.	Leave	0.3	Beta-	36,000				The ratchet binder on the left side of the skid had
	Ship#	015	ICV	Maint	He	to CFA	04/14/88	to INEL	4	TMI	47	None	TMI		Gamma					two ball detent pins that did not function properly.
027	Cask#	001-1T				to TAN	04/14/88	at CFA	0	INEL	7		Arrive	0.5	ICV	3	0.50	None	None	
	Car#	IDOX-100				to CFA	04/20/88	at TAN	6	Ship	10	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	04/21/88	at CFA	1	Cycle	64	None	Empty	0.1	Decon	No				
	(lbs)	4944				at TMI	04/27/88	to TMI	6				to TMI							

Cask Ship No.	Rail Ship No Cask No. Rail Car No Can. Payload		Cask Leak Tests	Assbl/ Maint	Cover Gas	Cask Shipment: Movement	(Date)	Duration	(Days)	Total Days		Inspection & Maintenance (Date)	Max. Rad. Level at Contact	(mR/h)	Maximum Internal Contamination	(dpm/100cm2)	Water in ICV (gal)	TMI MNCRs	INEL NCRs	Comments
028	Ship# Cask# Car# Can P. (lbs)	015 002-1T 1DOX-101 1111	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	04/10/88 04/14/88 04/20/88 04/25/88 04/26/88 05/03/88	to INEL at CFA at TAN at CFA to TMI	4 6 5 1 7	TMI INEL Ship Cycle	34 12 11 57	Car Insp. , None Cask Maint. None	Leave TMI Arrive INEL Empty to TMI	<0.1 0.2 0.1	Beta-Gamma ICV Posi. Decon	97,000 3 No	0.26	None	None	
029	Ship# Cask# Car# Can P. (lbs)	016 002-1T 1DOX-101 5376	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	05/22/88 05/26/88 06/10/88 06/16/88 06/18/88 06/25/88	to INEL at CFA at TAN at CFA to TMI	4 15 6 2 7	TMI INEL Ship Cycle	19 23 11 53	Car Insp. On-site Cask Maint. None	Leave TMI Arrive INEL Empty to TMI	2.2 3.5 0.1	Beta-Gamma ICV Posi. Decon	36,300 3 No	0.30	None	TM-4983 UOR EGG-88-15	Walking beam on trailer broke--replaced both sides.
030	Ship# Cask# Car# Can P. (lbs)	016 003-3215 NPIX-100 3230	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	05/22/88 05/26/88 06/16/88 06/22/88 06/25/88 07/03/88	to INEL at CFA at TAN at CFA to TMI	4 21 6 3 8	TMI INEL Ship Cycle	13 30 12 55	Car Insp. On-site Cask Maint. None	Leave TMI Arrive INEL Empty to TMI	0.6 1.2 0.1	Beta-Gamma ICV Posi. Decon	22,240 2 No	0.70	None	TM-4985/4986	One lanyard repaired. Canister grapple trouble.
031	Ship# Cask# Car# Can P. (lbs)	016 001-1T 1DOX-100 4590	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	05/22/88 05/26/88 06/23/88 06/28/88 07/02/88 07/11/88	to INEL at CFA at TAN at CFA to TMI	4 28 5 4 9	TMI INEL Ship Cycle	25 37 13 75	Car Insp. Maint Cask Maint. None	Leave TMI Arrive INEL Empty to TMI	1.2 1.2 0.1	Beta-Gamma ICV Posi. Decon	9,580 4 No	0.30	None	TM-4987	Delays due to high winds. Canister grapple trouble.
032	Ship# Cask# Car# Can P. (lbs)	017 001-1T 1DOX-100 3799	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	12/18/88 12/22/88 01/03/89 01/12/89 01/14/89 01/25/89	to INEL at CFA at TAN at CFA to TMI	4 12 9 2 11	TMI INEL Ship Cycle	160 23 15 198	Car Insp. On-site Cask Maint. 01/11/89	Leave TMI Arrive INEL Empty to TMI	0.7 1.0 0.1	Beta-Gamma ICV Posi. Decon	14,000 6 No	0.15	None	None	Semi-annual PM lower trunnions and & Micerta inserts; Delays from TMI - Thaxton Plugs & cask seals; INEL - Weather, crane, O-Man, grapple, 3 shield plugs removed/rework
033	Ship# Cask# Car# Can P. (lbs)	017 003-3215 NPIX-100 1697	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	12/18/88 12/22/88 01/16/89 01/18/89 01/21/89 01/27/89	to INEL at CFA at TAN at CFA to TMI	4 25 2 3 6	TMI INEL Ship Cycle	168 30 10 208	Car Insp. On-site Cask Maint. 01/17/89	Leave TMI Arrive INEL Empty to TMI	0.4 0.2 <0.1	Beta-Gamma ICV Posi. Decon	27,300 5 No	Ice	None	None	Semi-annual PM lower trunnions and & Micerta inserts; Delays from TMI - Thaxton Plugs & cask seals; Ice on ICV
034	Ship# Cask# Car# Can P. (lbs)	017 002-1T 1DOX-101 2809	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	12/18/88 12/22/88 01/18/89 01/24/89 01/28/89 02/06/89	to INEL at CFA at TAN at CFA to TMI	4 27 6 4 9	TMI INEL Ship Cycle	176 37 13 226	Car Insp. 01/30/89 Cask Maint. 01/24/89	Leave TMI Arrive INEL Empty to TMI	0.5 1.5 0.1	Beta-Gamma ICV Posi. Decon	55,000 3 No	0.17	None	None	Semi-annual PM lower trunnions and & Micerta inserts; Delays from TMI - Thaxton Plugs & cask seals; Replaced Environmental Cover. Repaired skid tie down handle, Separated lower impact limiter (port 3)
035	Ship# Cask# Car# Can P. (lbs)	18 001-1T 1DOX-100 7143	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	02/19/89 02/23/89 03/01/89 03/07/89 03/11/89 03/18/89	to INEL at CFA at TAN at CFA to TMI	4 6 6 4 7	TMI INEL Ship Cycle	239 16 11 266	Car Insp. On Site Cask Maint. No	Leave TMI Arrive INEL Empty to TMI	1.5 2.0 0.1	Beta-Gamma ICV Posi. Decon	48,120 4 No	0.68	0	None	
036	Ship# Cask# Car# Can P. (lbs)	18 002-1T 1DOX-101 3232	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	02/19/89 02/23/89 03/07/89 03/13/89 03/18/89 03/28/89	to INEL at CFA at TAN at CFA to TMI	4 12 6 5 10	TMI INEL Ship Cycle	232 23 14 269	Car Insp. On Site Cask Maint. No	Leave TMI Arrive INEL Empty to TMI	0.2 1.5 0.1	Beta-Gamma ICV Posi. Decon	143,000 2 No	0.75	None	None	

Cask Ship No.	Rail Ship No. / Cask No / Rail Car No / Can. Payload		Cask Leak Tests	Assbl/ Maint	Cover Gas	Cask Shipment: Movement	(Date)	Duration	(Days)	Total Days		Inspection & Maintenance (Date)	Max. Rad. Level at Contact	(mR/h)	Maximum Internal Contamination	(dpm/100cm2)	Water in ICV (gal)	TMI NNCRs	INEL NCRs	Comments
						from TMI	02/19/89					Car Insp.	Leave	0.5	Beta-	6,680				DOE observed railcar PM at Pocatello.
	Ship#	018	ICV	Maint	He	to CFA	02/23/89	to INEL	4	TMI	25	03/03/89	TMI		Gamma		0.25	None	None	Overpack bolt F5 replaced. See letter AYE-16-89
	Cask#	003-3215				to TAN	02/23/89	at CFA	0	INEL	17		Arrive	0.5	ICV	C				
37	Car#	NPIX-100				to CFA	03/01/89	at TAN	6	Ship	12	Cask Maint.	INEL		Posi.					
	Can P		OCV	Maint	He	from INEL	03/04/89	at CFA	3	Cycle	54	No	Empty		Decon	No				
	(lbs)	3340				at TMI	03/12/89	to TMI	8				to TMI	0.1						
						from TMI	06/18/89					Car Insp.	Leave	0.5	Beta-	36,000				Railroad detour in transit. Rail car: crack between
	Ship#	019	ICV	Maint	He	to CFA	06/22/89	to INEL	4	TMI	82	06/26/89	TMI		Gamma		0.39	None	TM-	end seal and center seal weld.
38	Cask#	002-IT				to TAN	06/22/89	at CFA	0	INEL	16		Arrive	0.5	ICV	C			5019	Replaced a ball detent pin on the skid
	Car#	IDX-101				to CFA	06/28/89	at TAN	6	Ship	11	Cask Maint.	INEL		Posi.					Installed reworked shield plug.
	Can P.		OCV	Maint	hE	from INEL	07/01/89	at CFA	3	Cycle	109	Onsite	Empty	<0.1	Decon	No				Semi annual PM lower trunions and micarta inserts.
	(lbs)	6130				at TMI	07/08/89	to TMI	7				to TMI							
						from TMI	06/18/89					Car Insp.	Leave	0.7	Beta-	39,280				Railroad detour in transit.
	Ship#	019	ICV	Maint	He	to CFA	06/22/89	to INEL	4	TMI	98	06/24/89	TMI		Gamma		0.89	None	None	
39	Cask#	003-3215				to TAN	06/28/89	at CFA	6	INEL	23		Arrive	0.7	ICV	5				Semi annual PM lower trunions and micarta inserts
	Car#	NPIX-100				to CFA	07/07/89	at TAN	9	Ship	11	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	07/08/89	at CFA	1	Cycle	132	Onsite	Empty	0.1	Decon	No				
	(lbs)	9285				at TMI	07/15/89	to TMI	7				to TMI							
						from TMI	06/18/89					Car Insp.	Leave	1.5	Beta-	60,000				Railroad detour in transit.
	Ship#	019	ICV	Maint	He	to CFA	06/22/89	to INEL	4	TMI	92	07/17/89	TMI		Gamma		0.08	None	None	An environmental cover had been damaged prior to
40	Cask#	001-IT				to TAN	07/10/89	at CFA	18	INEL	31		Arrive	1.2	ICV	C				arrival at INEL.
	Car#	IDOX 100				to CFA	07/13/89	at TAN	3	Ship	12	Cask Maint.	INEL		Posi.					Semi annual PM lower trunions and micarta inserts.
	Can P.		OCV	Maint	He	from INEL	07/15/89	at CFA	2	Cycle	135	07/11/89	Empty	0.1	Decon	No				
	(lbs)	5700				at TMI	07/23/89	to TMI	8				to TMI							
						from TMI	08/13/89					Car Insp.	Leave	<0.1	Beta-	110,580				D-342 had contamination levels higher than limits speci
	Ship#	20	ICV	Maint	He	to CFA	08/16/89	to INEL	3	TMI	36	On-site	TMI		Gamma		0.29	None	None	
41	Cask#	002-IT				to TAN	08/17/89	at CFA	1	INEL	15		Arrive	1	ICV	4				
	Car#	IDOX 100				to CFA	08/23/89	at TAN	6	Ship	8	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	08/26/89	at CFA	3	Cycle	59		Empty		Decon	No				
	(lbs)	10,623				at TMI	08/31/89	to TMI	5			No	to TMI	<0.1						
						from TMI	08/13/89					Car Insp.	Leave	0.2	Beta-	4,500				
	Ship#	20	ICV	Maint	He	to CFA	08/16/89	to INEL	3	TMI	30	On-site	TMI		Gamma		0.73	None	None	
42	Cask#	003-3215				to TAN	08/24/89	at CFA	8	INEL	22		Arrive	0.8	ICV	C				
	Car#	NPIX-100				to CFA	08/30/89	at TAN	6	Ship	9	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	09/01/89	at CFA	2	Cycle	61	No	Empty	<0.1	Decon	No				
	(lbs)	11,066				at TMI	09/07/89	to TMI	6				to TMI							
						from TMI	08/13/89					Car Insp.	Leave	1.0	Beta-	100,000				
	Ship#	20	ICV	Maint	He	to CFA	08/16/89	to INEL	3	TMI	21	09/11/89	TMI		Gamma		0.40	None	None	
43	Cask#	002-IT				to TAN	08/31/89	at CFA	15	INEL	33		Arrive	0.9	ICV	3				
	Car#	IDOX-101				to CFA	09/07/89	at TAN	7	Ship	12	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	09/09/89	at CFA	2	Cycle	66	No	Empty	<0.1	Decon	No				
	(lbs)	10,995				at TMI	09/18/89	to TMI	9				to TMI							
						from TMI	12/17/89					Car Insp.	Leave	0.5	Beta-	5,760				F-453 High Contamination
	Ship#	21	ICV	Maint	He	to CFA	12/21/89	to INEL	4	TMI	108	Pocatello	TMI		Gamma		0.16	None	None	Grey film and high radiation readings in ICU canister
44	Cask#	001-IT				to TAN	02/01/90	at CFA	42	INEL	65		Arrive	0.8	ICV	4				ports
	Car#	IDOX-100				to CFA	02/07/90	at TAN	6	Ship	11	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	02/17/90	at CFA	10	Cycle	184	No	Empty	0.1	Decon	No				
	(lbs)	16,876				at TMI	02/24/90	to TMI	7				to TMI							
						from TMI	12/17/89					Car Insp.	Leave	0.8	Beta-	56,820				D-379, D-364, D-391 F-419--High Contamination levels
	Ship#	21	ICV	Maint	He	to CFA	12/21/89	to INEL	4	TMI	90	On-Site	TMI		Gamma		0.19	None	None	Empty canister parts reading 10 m/k before
	Cask#	002-IT				to TAN	01/11/90	at CFA	21	INEL	51		Arrive	0.8	ICV	3				contamination
45	Car#	IDOX-100				to CFA	01/31/90	at TAN	20	Ship	11	Cask Maint.	INEL		Posi.					
	Can P.		OCV	Maint	He	from INEL	02/03/90	at CFA	3	Cycle	152	No	Empty	0.1	Decon	No				
	(lbs)	17,743				at TMI	02/10/90	to TMI	7				to TMI							

Cask Ship No.	Rail Ship No. Cask No. Rail Car No. Can. Payload		Cask Leak Tests	Assbl/ Maint	Cover Gas	Cask Shipment Movement	(Date)	Duration	(Days)	Total Days		Inspection & Maintenance (Date)	Max. Rad. Level at Contact	(mR/h)	Maximum Internal Contamination (dpm/100cm2)		Water in ICV (gal)	TMI MNCRs	INEL NCRs	Comments
46	Ship# Cask# Car# Can P. (lbs)	21 003-3215 NPIX-100 17,824	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	12/17/89 12/21/89 02/13/90 02/20/90 02/24/90 03/05/90	to INEL at CFA at TAN at CFA to TMI	4 54 7 4 9	TMI INEL Ship Cycle	101 74 13 188	Car Insp. On-Site Cask Maint. No	Leave TMI Arrive INEL Empty to TMI	0.7 0.1 0.1	Beta-Gamma ICV Posi. Decon	80,000 6 No	0.56	None	TM-5032	Tarp was torn and replaced Gouged skid
47	Ship# Cask# Car# Can P. (lbs)	22 D03-3215 NPIX-100 7,139	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	04/15/90 04/18/90 04/19/90 04/25/90 04/28/90 05/06/90	to INEL at CFA at TAN at CFA to TMI	3 1 6 3 8	TMI INEL Ship Cycle	41 18 11 70	Car Insp. On Site Cask Maint. N/A	Leave TMI Arrive INEL Empty to TMI	0.5 0.6 0.1	Beta-Gamma ICV Posi. Decon	< 100,000 ---------- None ---------- None	0.13	None	None	
48	Ship# Cask# Car# Can P. (lbs)	22 002-1T IDOX-101	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	04/15/90 04/18/90 05/02/90 05/09/90 STORAGE N/A	to INEL at CFA at TAN at CFA to TMI	3 14 7 0 0	TMI INEL Ship Cycle	64 21 3 88	Car Insp. N/A Cask Maint. N/A	Leave TMI Arrive INEL Empty to TMI	0.5 0.6 N/A	Beta-Gamma ICV Posi. Decon	< 100,000 ---------- 3 ---------- All	0.76	None	None	Cask placed in storage at INEL
49	Ship# Cask# Car# Can P. (lbs)	22 001-1T IDOX-100 3185	ICV OCV	Maint Maint	He He	from TMI to CFA to TAN to CFA from INEL at TMI	04/15/90 04/18/90 04/25/90 05/02/90 STORAGE N/A	to INEL at CFA at TAN at CFA to TMI	3 7 7 0 0	TMI INEL Ship Cycle	50 14 3 67	Car Insp. N/A Cask Maint. N/A	Leave TMI Arrive INEL Empty to TMI	0.7 0.1 N/A	Beta-Gamma ICV Posi. Decon	322,000 ---------- 3 ---------- All	0.32	None	None	Cask placed in storage at INEL

Appendix K

Canister Gas Generation Sampling Results

(GPU Nuclear letter to the Nuclear Regulatory Commission, 4410-87-L-0127/0214P, October 21, 1987)

GPU Nuclear

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October 21, 1987
4410-87-L-0127/0214P

US Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Dear Sirs:

Three Mile Island Nuclear Station, Unit 2 (TMI-2)
Operating License No. DPR-73
Docket No. 50-320
Defueling Canister Gas Sampling

The purpose of this letter is to request NRC approval to discontinue the long-term gas sampling program at the Idaho National Engineering Laboratory (INEL).

The NRC TMICPD Letter NRC/TMI-87-003, dated January 7, 1987, approved a GPU Nuclear request to reduce the required canister void volume to 25% for fuel canisters and to levels assuring exposure of 25 grams of recombiner catalyst for filter and knockout canisters. The NRC approval was granted provided the following conditions were met:

1. Canisters would be dewatered to the maximum extent practical.

2. After shipping, confirmatory gas measurements would be taken on one (1) canister per shipment (i.e., one (1) of seven (7) for a single cask shipment, one (1) of 14 for a double cask shipment). A gas sample would be withdrawn and analyzed shortly after (i.e., within a few days) removal of the canister from the shipping cask at the INEL. Subsequently, the canister would be stored in an unvented condition for about six (6) weeks and resampled. The gas sample analysis would be used to confirm the conservatism in the projected allowable shipping window, as determined by comparison with gas samples withdrawn prior to shipping.

3. The sample results would be made available for NRC review upon request.

The intent of the long-term gas sampling program described above in item No. 2 is to verify 1) the catalyst recombiner is functioning under shipping conditions, 2) a combustible mixture of oxygen and hydrogen is not being shipped, and 3) the absence of an excessive pressure rise in the canisters due to a net hydrogen increase. Based on the justification provided below, GPU Nuclear believes that the long-term gas sampling program is no longer necessary.

To date, a total of eight (8) canisters have been sampled at INEL (several of the canisters have been sampled several times). Attachment 1 presents the gas sample results from both TMI and INEL in tabular form. This table provides the number of gas samples per canister at TMI and INEL, the number of days between samples, and the gas sample chemical analysis results. Attachment 2 graphically displays the gas sample data of Attachment 1. The graphs compare the percentage of hydrogen and oxygen present in the TMI and INEL samples as a function of the number of days after dewatering.

The following conclusions can be made from reviewing the attachments:

- At no time during the sampling program was a combustible mixture of gas approached.

- In each case, the sample results obtained at TMI are conservative in determining the gas appearance rate, i.e., if employing the single point straight line projection shown in Attachment 2, the safe storage time calculated using the TMI data is less than the safe storage time calculated using the INEL data.

- In all cases where oxygen scavenging was apparent, the hydrogen appearance rate was found to be less than 10 percent of the theoretical maximum used in previous analyses.

- A pressure increase due to net hydrogen production is not detectable. After dewatering, the canisters are overpressurized with argon to approximately 2 atm (29.4 psi). The highest canister pressure that has been observed at INEL is 29.33 psi (i.e., also approximately 2 atm). The canister design pressure is 150 psig.

GPU Nuclear believes that the data generated at INEL on the eight (8) canisters sampled, provides a sufficient data base to conclude that no safety hazards exist due to combustible gas mixtures or canister overpressurization. The safe shipment time calculated at TMI is more than adequate to meet the requirements of the NuPac 125B Certificate of Compliance (C of C) and the Canister Handling and Preparation for Shipment Safety Evaluation Report. Therefore, GPU Nuclear requests approval to discontinue the long-term sampling program at INEL.

Per the requirements of 10 CFR 170, an application fee of $150.00 is enclosed.

Sincerely,

/s/ T. F. Demmitt for

F. R. Standerfer
Director, TMI-2

CJD/eml

Attachment

Enclosed: GPU Nuclear Corp. Check No. 007606

cc: Regional Administrator, Region 1 - W. T. Russell
Director, TMI-2 Cleanup Project Directorate - Dr. W. D. Travers

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TMI-2 GAS SAMPLE CANISTER INFORMATION

Cani. Head No.	Cask Ship No.	Rail Ship No.	Cani. Void Volume (ft3)	DeH2O Wt. (lbs)	Activity			Date	Days Moni-tored	Cani. Pressure (psia)	Water Temp. (F)	Sample Cylin-der No.	Chemical Analysis (%) H2	N2	O2	Ar	CO2	He
D-144	003	--	3.38	2607	TMI	1st DeH2O	post	07/14/86	0	29.49	72	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	2nd DeH2O	pre	07/26/86	12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	2nd DeH2O	post	07/26/86	0	N/A	N/A							
					TMI	Final DeH2O	pre	08/13/86	18	29.54	75	N/A	0.35	0.90	0.25	N/A	N/A	N/A
					TMI	Final DeH2O	post	08/13/86		29.44	75							
					TMI	Final DeH2O **	post	08/19/86	0	29.54 *	75							
					INEL		Start	01/13/87	147	26.33	68	2	0.77	0.90	0.08	98.2	0.03	N/A
					INEL		Finish	01/13/87		26.33	68	3	0.77	0.90	0.07	98.2	0.03	N/A
D-148	006	4	2.85	2781	TMI	1st DeH2O	post	11/21/86	0	29.54	65	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	2nd DeH2O	pre	12/05/86	14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	2nd DeH2O	post	12/05/86	0	29.54	65							
					TMI	Final DeH2O	pre	01/02/87	28	28.24	68	N/A	1.03	<0.21	<0.12	N/A	N/A	N/A
					TMI	Final DeH2O	post	01/02/87	0	29.52	68							
					INEL	1st	Start	01/28/87	26	29.13	68	2	1.14	0.35	0.07	98.4	0.05	N/A
					INEL	1st	Finish	01/28/87		28.53	68	3	1.15	0.36	0.06	98.4	0.05	N/A
					INEL	2nd	Start	02/19/87	48	28.83	68	2	1.46	0.71	0.13	97.7	NEG	N/A
					INEL	2nd	Finish	02/19/87		28.83	68	3	1.48	0.69	0.13	97.7	NEG	N/A
D-145	007	5	2.79	2776	TMI	1st DeH2O	post	01/15/87	0	29.44	65	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	Final DeH2O	pre	01/23/87	8	28.54	64	N/A	0.35	0.74	<0.11	N/A	N/A	N/A
					TMI	Final DeH2O	post	01/23/87	0	29.54	64							
					INEL		Start	02/19/87	27	29.33	68	4	0.74	0.59	0.09	98.6	NEG	N/A
					INEL		Finish	02/19/87		29.33	68	5	0.74	0.58	0.09	98.6	NEG	N/A
D-180	008	6	2.55	2899	TMI	1st DeH2O	post	01/12/87	0	29.44	64	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	Final DeH2O	pre	02/07/87	26	28.64	66	N/A	0.72	1.60	<0.2	N/A	N/A	N/A
					TMI	Final DeH2O	post	02/07/87	0	29.38	66							
					INEL	1st	Start	03/06/87	27	*18.33	68	2	1.19	1.04	0.13	97.60	0.02	N/A
					INEL	1st	Finish	03/06/87		*18.33	68	3	1.22	1.10	0.13	97.40	0.03	N/A
					INEL	2nd	Start	08/31/87	205	19.33	70	10	9.05	3.73	<0.01	87.21	<0.01	<0.01
					INEL	2nd	Finish	08/31/87		19.33	70	11	9.05	3.76	0.02	87.17	<0.01	<0.01

Cani. Head No.	Activ-ity	Days between Sample	Gas Vol Gen/Leak Rate (cc/hr)	Hydrogen Gen. Rate (cc/hr)	Comments
D-144	TMI 1st to 2nd	12	N/A	N/A	Gas sampled for information only.
	TMI 2nd to Fin	18	N/A	1.43417	* Estimated value (Water temp. was not measured).
	TMI to INEL	147	-4.8586	0.34893	** Re-pressurized to 15 psi for canister leakage.
					Finished gas sampling.
D-148	TMI 1st to 2nd	14	N/A	N/A	
	TMI 2nd to Fin.	28	-11.192	2.21613	
	TMI to INEL	26	-3.1999	2.73668	
	INEL 1st to 2nd	22	2.90904	0.94187	
					Finished gas sampling.
D-145	TMI 1st to Fin.	8	-22.196	2.62754	Only one sample taken at INEL.
	TMI to INEL	27	-3.3707	1.67877	
					Finished gas sampling.
D-180	TMI 1st to Fin.	26	-6.7265	1.51960	
	TMI to INEL	27	N/A	N/A	* Gas pressure: Estimated value (for a defect of the pressure gage)
	INEL 1st to 2nd	178	0.99400	1.62703	

K-7

Cani. Head No.	Cask Ship No.	Rail Ship No.	Cani. Void Volume (ft3)	DeH2O Wt. (lbs)	Site	Activity		Date	Days Monitored	Cani. Pressure (psia)	Water Temp. (F)	Sample Cylinder No.	Chemical Analysis % H2	N2	O2	Ar	CO2	He
D-162	009	7	2.74	2831	TMI	1st DeH2O	post	02/13/87	0	29.32	66	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	Final DeH2O	pre	03/03/87	18	29.04	66	N/A	0.52	0.44	<0.13	N/A	N/A	N/A
					TMI		post	03/03/87	0	29.5	66							
					INEL	1st	Start	04/08/87	36	29.33	68	4	1.01	4.29	1.00	93.62	0.07	0.01
					INEL		Finish	04/08/87		29.33	68	5	1.00	4.43	1.04	93.44	0.07	0.01
					INEL	2nd	Start	08/31/87	181	28.33	70	8	1.01	2.22	<0.01	96.73	0.02	0.01
					INEL		Finish	08/31/87		28.33	70	9	1.01	2.22	<0.01	96.74	0.02	0.01

Cani. Head No.	Activity	Days between Sample	Gas Vol Gen/Leak Rate (cc/hr)	Hydrogen Gen. Rate (cc/hr)	Comments
D-162	TMI 1st to Fin.	18	-3.2025	1.72717	
	TMI to INEL	36	-1.6083	1.67932	
	INEL 1st to 2nd	145	-1.5650	-0.0137	

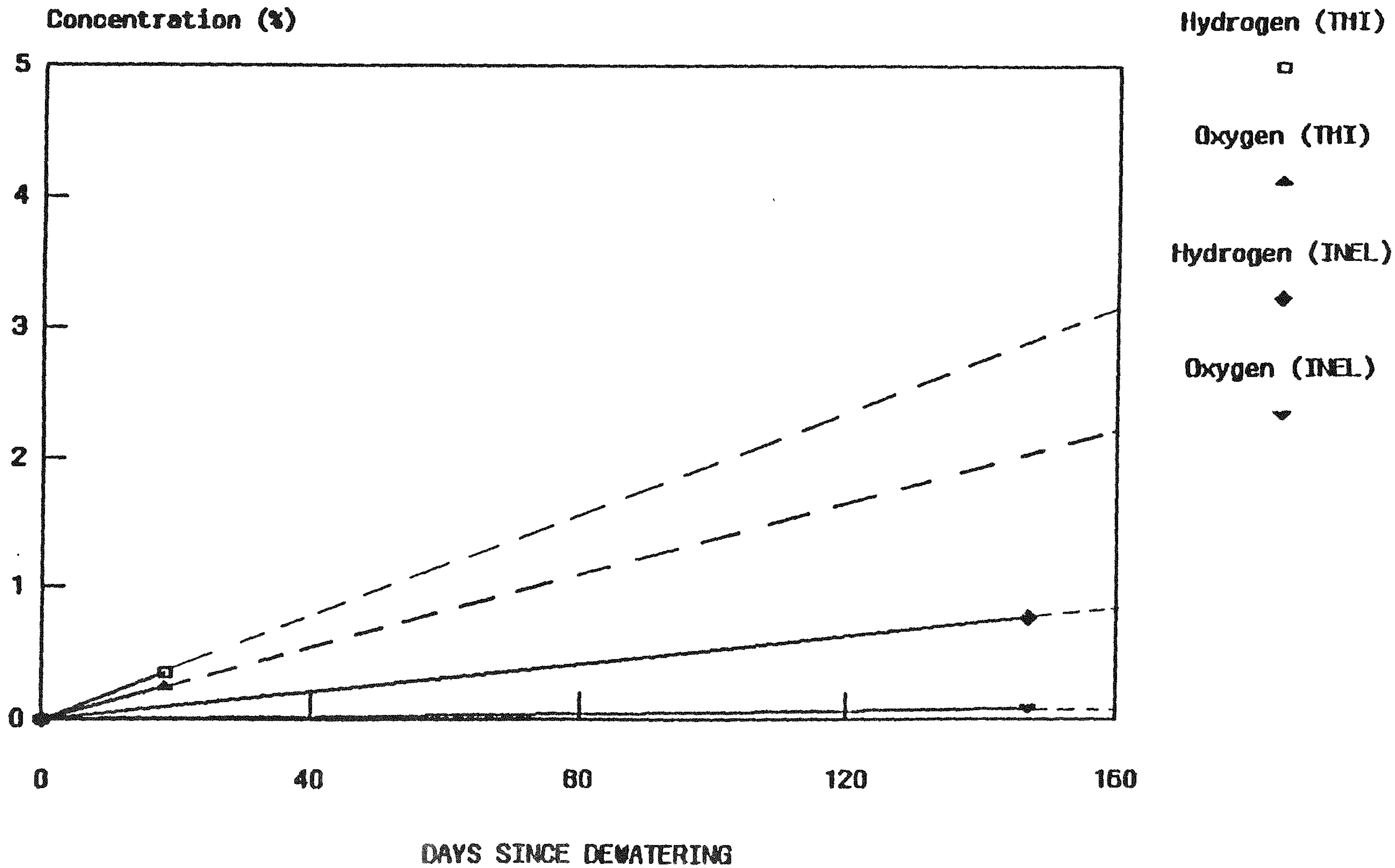
Cani. Head No.	Cask Ship No.	Rail Ship No.	Cani. Void Volume (ft3)	DeH2O Wt. (lbs)	Site	Activity		Date	Days Monitored	Cani. Pressure (psia)	Water Temp. (F)	Sample Cylinder No.	Chemical Analysis % H2	N2	O2	Ar	CO2	He
D-188	010	7	2.85	2902	TMI	1st DeH2O	post	01/12/87	0	29.3	64	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI	2nd DeH2O	pre	02/04/87	23	N/A	65	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					TMI		post	02/04/87	0	29.47	65							
					TMI	3rd DeH2O	pre	02/07/87	3	29.34	66	N/A	0.29	0.41	0.20	N/A	N/A	N/A
					TMI		post	02/07/87	0	29.33	66							
					TMI	4th DeH2O	pre	03/03/87	24	29.44	66	N/A	1.56	0.42	0.12	N/A	N/A	N/A
					TMI		post	03/03/87	0	29.36	66							
					TMI	5th DeH2O	pre	03/12/87	9	N/A	67	N/A	0.70	1.90	0.50	N/A	N/A	N/A
					TMI		post	03/12/87	0	29.39	67							
					TMI	Final DeH2O	pre	03/16/87	4	N/A	68	N/A	0.40	0.70	0.20	N/A	N/A	N/A
					TMI		post	03/16/87	0	29.36	68							
					INEL	1st	Start	04/01/87	16	29.33	68	4	1.16	0.49	0.05	98.27	0.01	N/A
					INEL		Finish	04/01/87		28.83	68	5	1.17	0.51	0.05	98.25	0.01	N/A
					INEL	2nd	Start	05/11/87	36	28.83	68	2	2.43	1.99	0.32	95.23	0.013	N/A
					INEL		Finish	05/11/87		28.83	68	3	2.43	1.91	0.29	95.35	0.012	N/A
					INEL	3rd	Start	06/12/87	88	28.33	68	4	3.30	2.17	0.26	94.24	0.01	0.02
					INEL		Finish	06/12/87		28.33	68	5	3.30	2.15	0.26	94.26	0.01	0.02
					INEL	4th	Start	08/31/87	168	27.33	70	14	5.07	1.83	<0.01	93.09	<0.01	<0.01
					INEL		Finish	08/31/87		27.33	70	15	5.10	1.79	<0.01	93.11	<0.01	<0.01

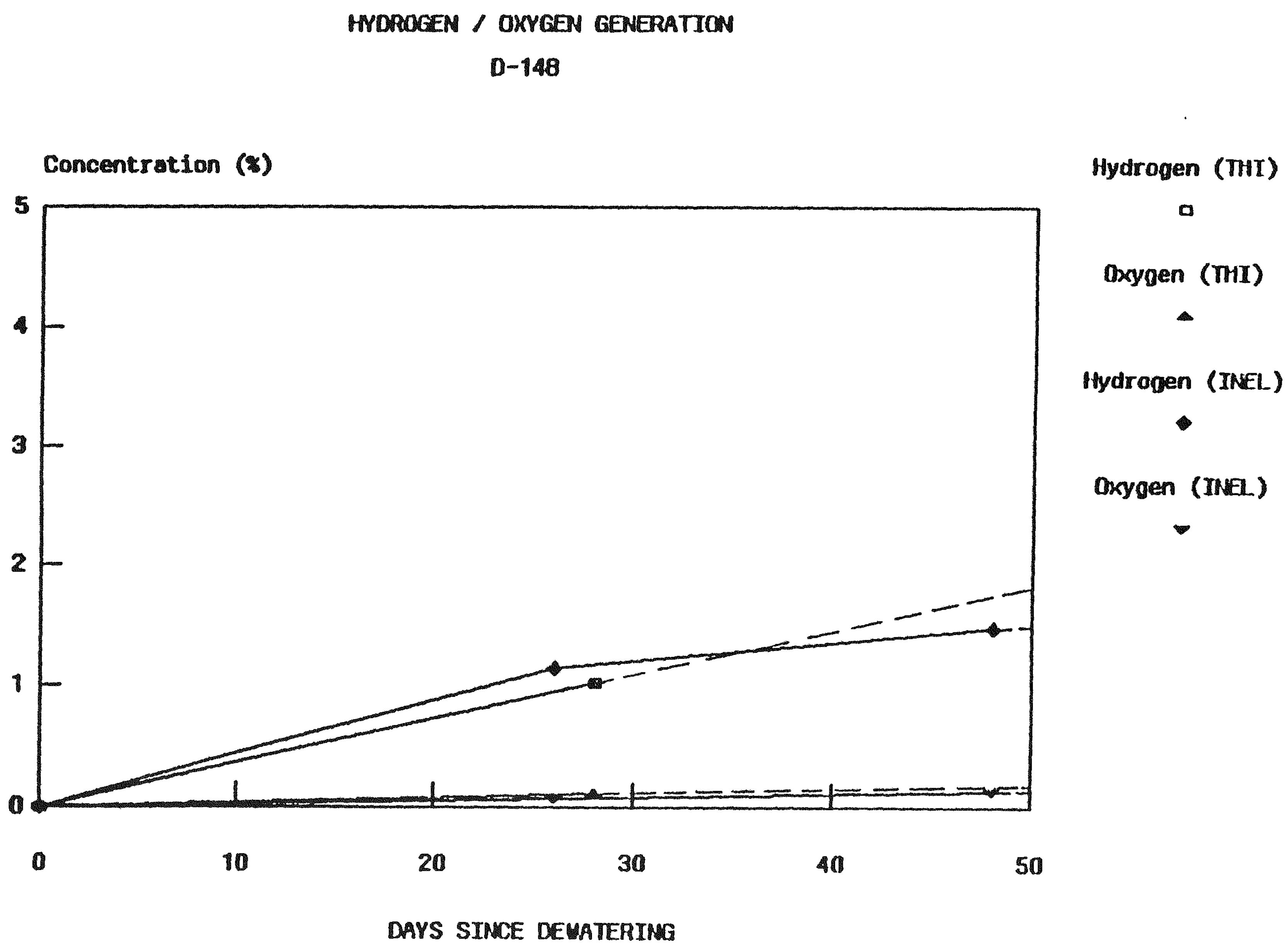
Cani. Head No.	Activity	Days between Sample	Gas Vol Gen/Leak Rate (cc/hr)	Hydrogen Gen. Rate (cc/hr)	Comments
D-188	TMI 1st to 2nd	23	N/A	N/A	
	TMI 2nd to 3rd	3	-13.291	6.07350	
	TMI 3rd to 4th	24	0.98148	4.09782	
	TMI 4th to 5th	9	N/A	N/A	
	TMI 5th to Fin.	4	N/A	N/A	
	TMI to INEL	16	-0.3999	4.55585	
	INEL 1st to 2nd	40	0	1.94503	
	INEL 2nd to 3rd	32	-3.3332	1.56211	
	to 3rd	80	-2.9420	1.19888	

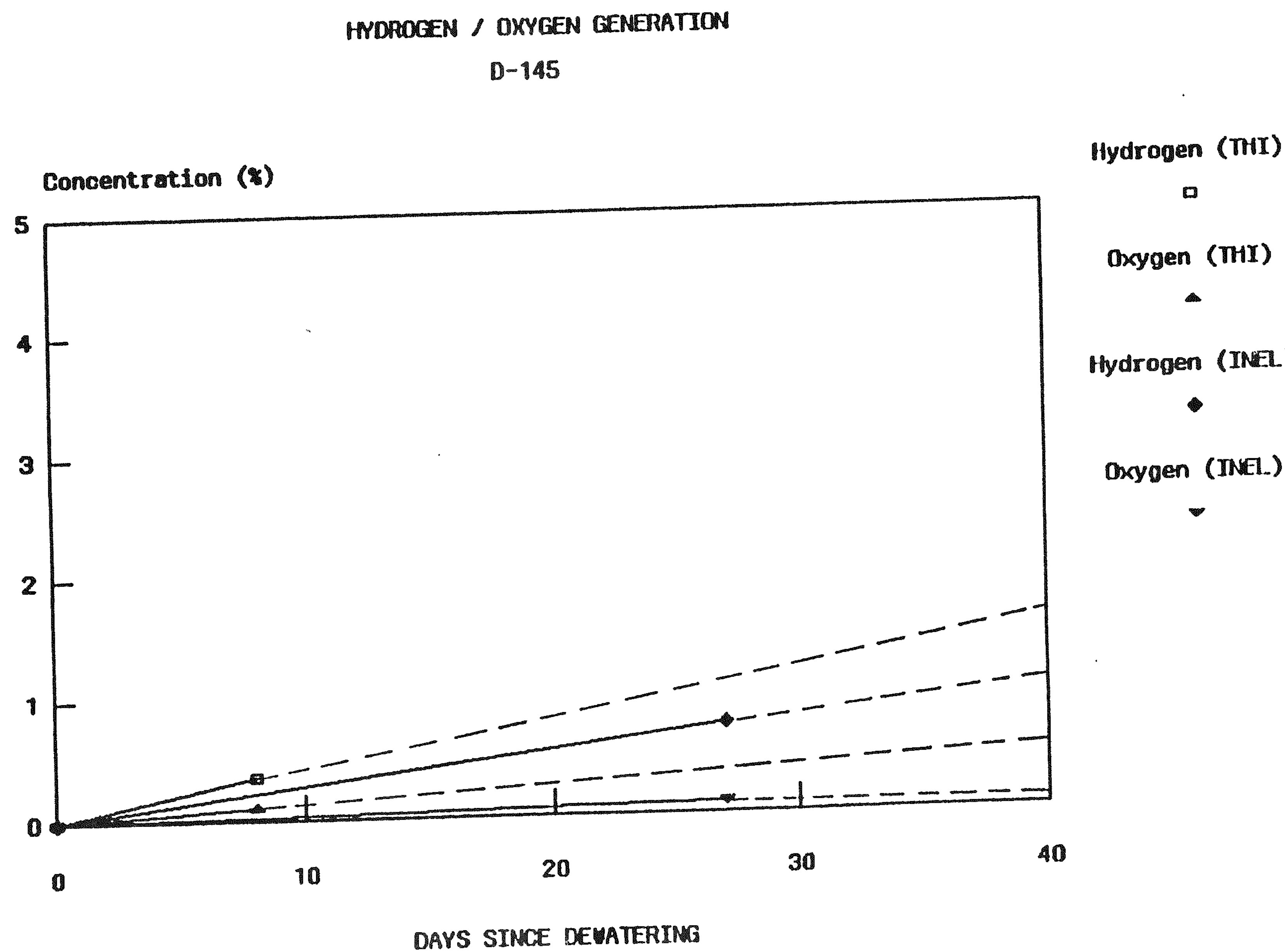
Cani. Head No.	Cask Ship No.	Rail Ship No.	Cani. Void Volume (ft3)	DeH2O Wt. (lbs)		Activity		Date	Days Moni-tored	Cani. Pressure (psia)	Water Temp. (F)	Sample Cylinder No.	H2	N2	O2	Ar	CO2	He	Activity	Days between Sample	Gas Vol Gen/Leak Rate (cc/hr)	Hydrogen Gen. Rate (cc/hr)	Comments
													Chemical Analysis %										
D-207	012	8	3.92		T	1st DeH2O	post	05/27/87	0	28.40	74	N/A	N/A	N/A	N/A	N/A	N/A	N/A	TMI 1st to Fin.	19	-53.444	6.46357	
					M	Final DeH2O	pre	06/15/87	19	25.04	77	N/A	1.70	<0.30	<0.20	N/A	N/A	N/A					
					I		post	06/16/87	0	29.34	77								TMI to INEL	20	7.07696	0.86060	
					I	1st	Start	07/06/87	20	29.33	68	4	0.20	0.48	0.04	93.40	0.13	5.70					
					N		Finish	07/06/87	0	28.33	68	5	0.20	0.47	0.04	93.40	0.13	5.70	INEL 1st to 2nd	56	-5.7807	0.35935	
					E	2nd	Start	08/31/87	~~56~~	27.33	70	6	0.46	3.73	0.69	89.76	0.08	5.28					
					L		Finish	08/31/87	76	27.33	70	7	0.46	3.90	0.74	89.55	0.07	5.28					
D-267	013	9	4.31		T	1st DeH2O	post	07/06/87	0	28.90	75	N/A	<0.01	<0.17	0.19	N/A	N/A	N/A	TMI 1st to Fin.	8	-35.468	0	
					M	Final DeH2O	pre	07/14/87	8	28.04	76	N/A	<0.007	2.46	0.69	N/A	N/A	N/A					
					I		post	07/15/87	0	29.33	75								TMI to INEL	22	-3.9940	0.47222	
					I	1st	Start	08/06/87	22	28.83	71	2	0.11	3.90	0.95	95.00	0.01	0.05					
					N		Finish	08/06/87	0	28.83	71	3	0.12	0.90	0.17	98.80	<0.01	0.05	INEL 1st to 2nd	25	-18.153	0.44244	
					E	2nd	Start	08/31/87	~~29~~	27.33	70	12	0.25	0.51	0.01	99.18	<0.01	0.06					
					L		Finish	08/31/87	47	27.33	70	13	0.25	0.52	0.01	99.16	<0.01	0.06					

HYDROGEN / OXYGEN GENERATION

D-144

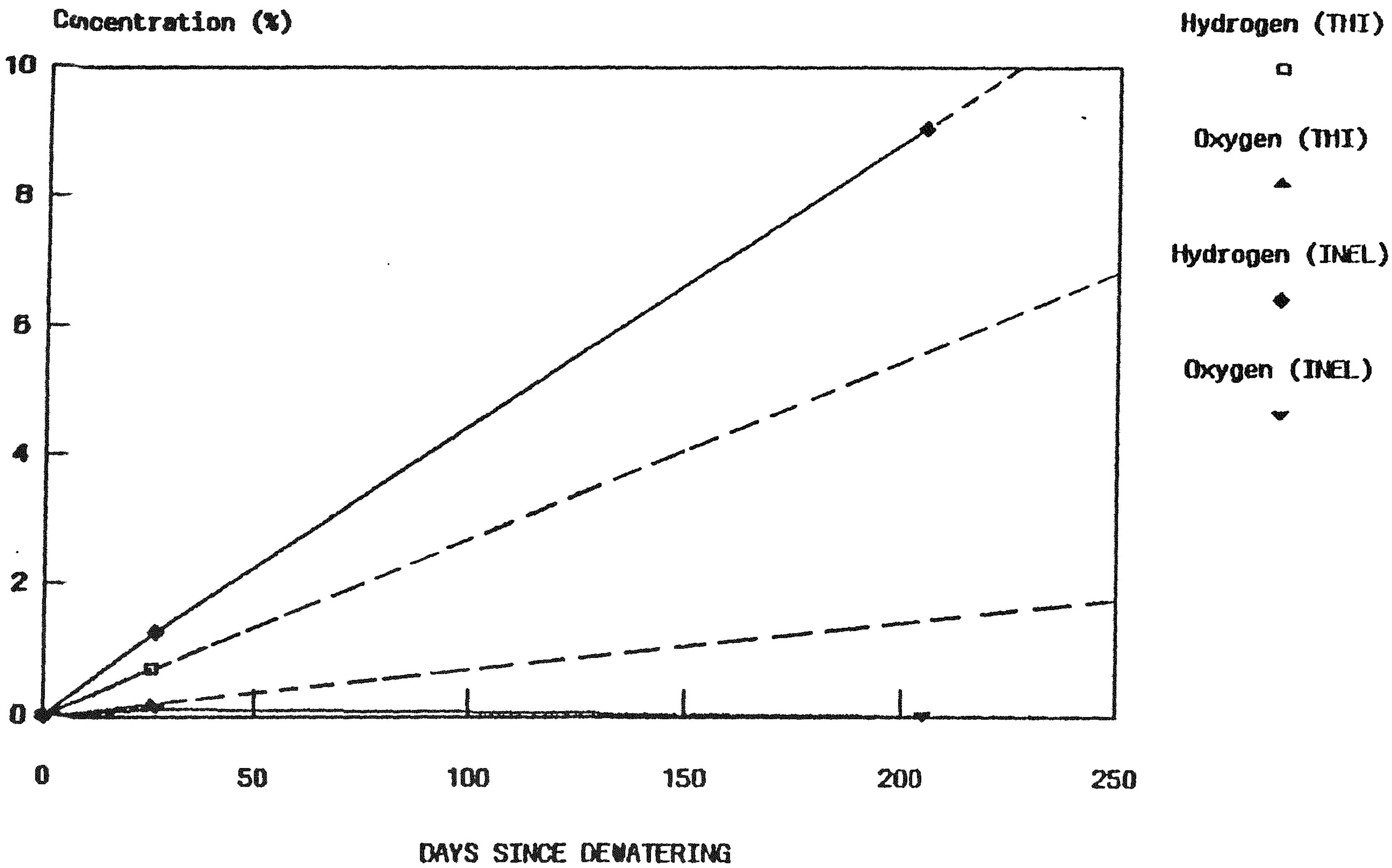



HYDROGEN / OXYGEN GENERATION
D-148
Concentration (%)
5
4
3
2
1
0
0
10
20
30
40
50
DAYS SINCE DEWATERING
Hydrogen (THI)
Oxygen (THI)
Hydrogen (INEL)
Oxygen (INEL)


HYDROGEN / OXYGEN GENERATION
D-145
Concentration (%)
5
4
3
2
1
0
0
10
20
30
40
DAYS SINCE DEWATERING
Hydrogen (THI)
Oxygen (THI)
Hydrogen (INEL)
Oxygen (INEL)

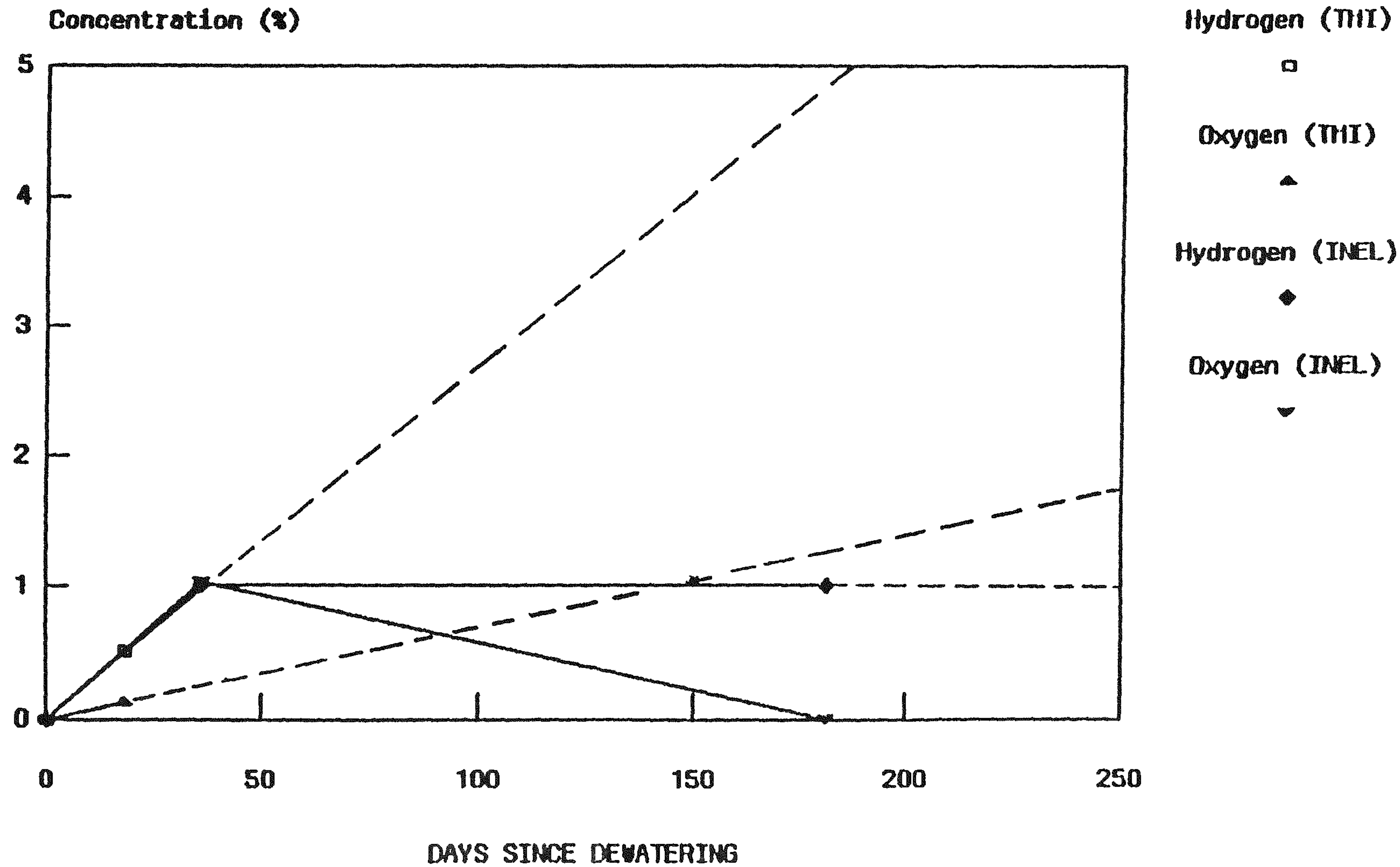
HYDROGEN / OXYGEN GENERATION

D-180



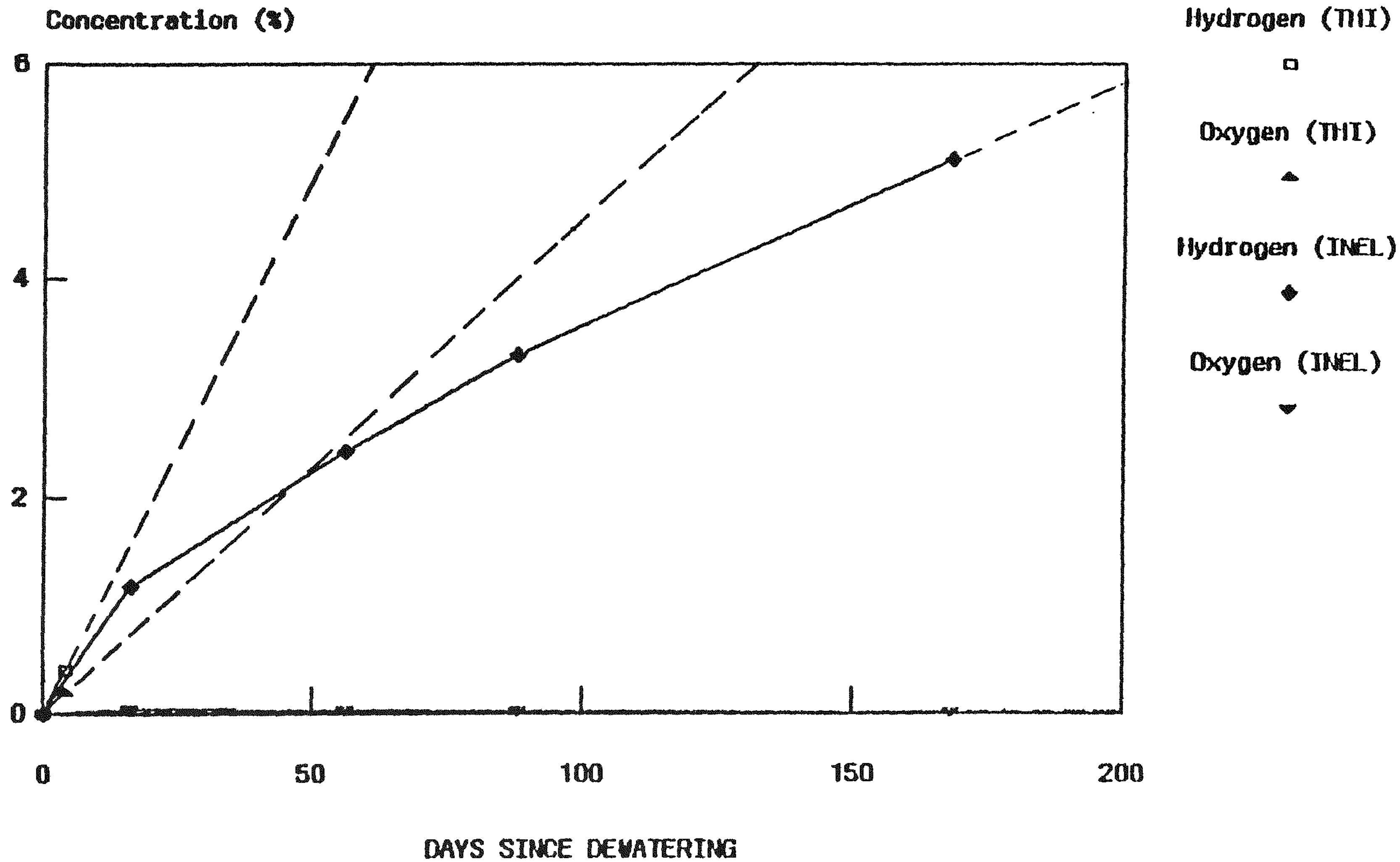
HYDROGEN / OXYGEN GENERATION

D-162



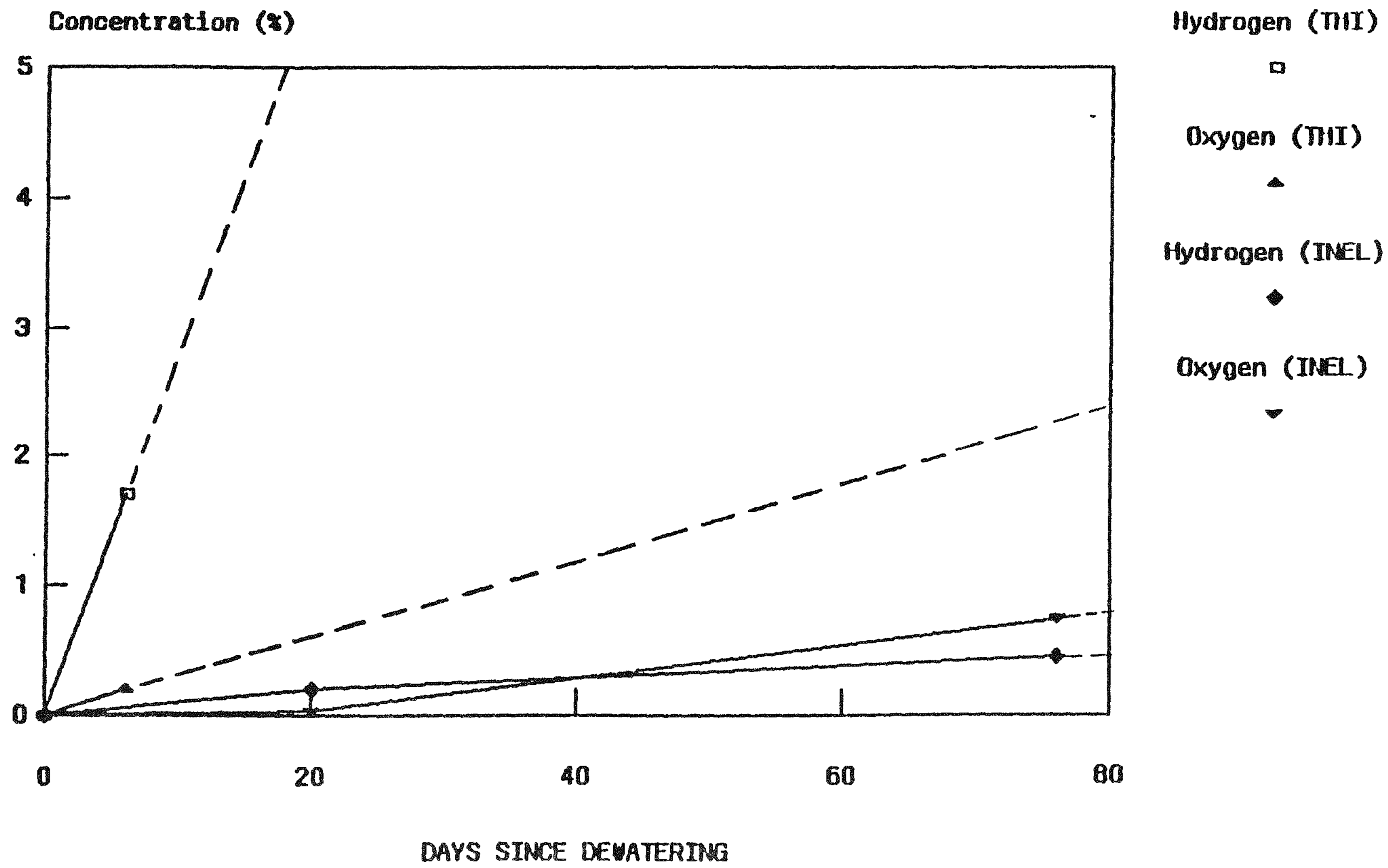
HYDROGEN / OXYGEN GENERATION

D-188



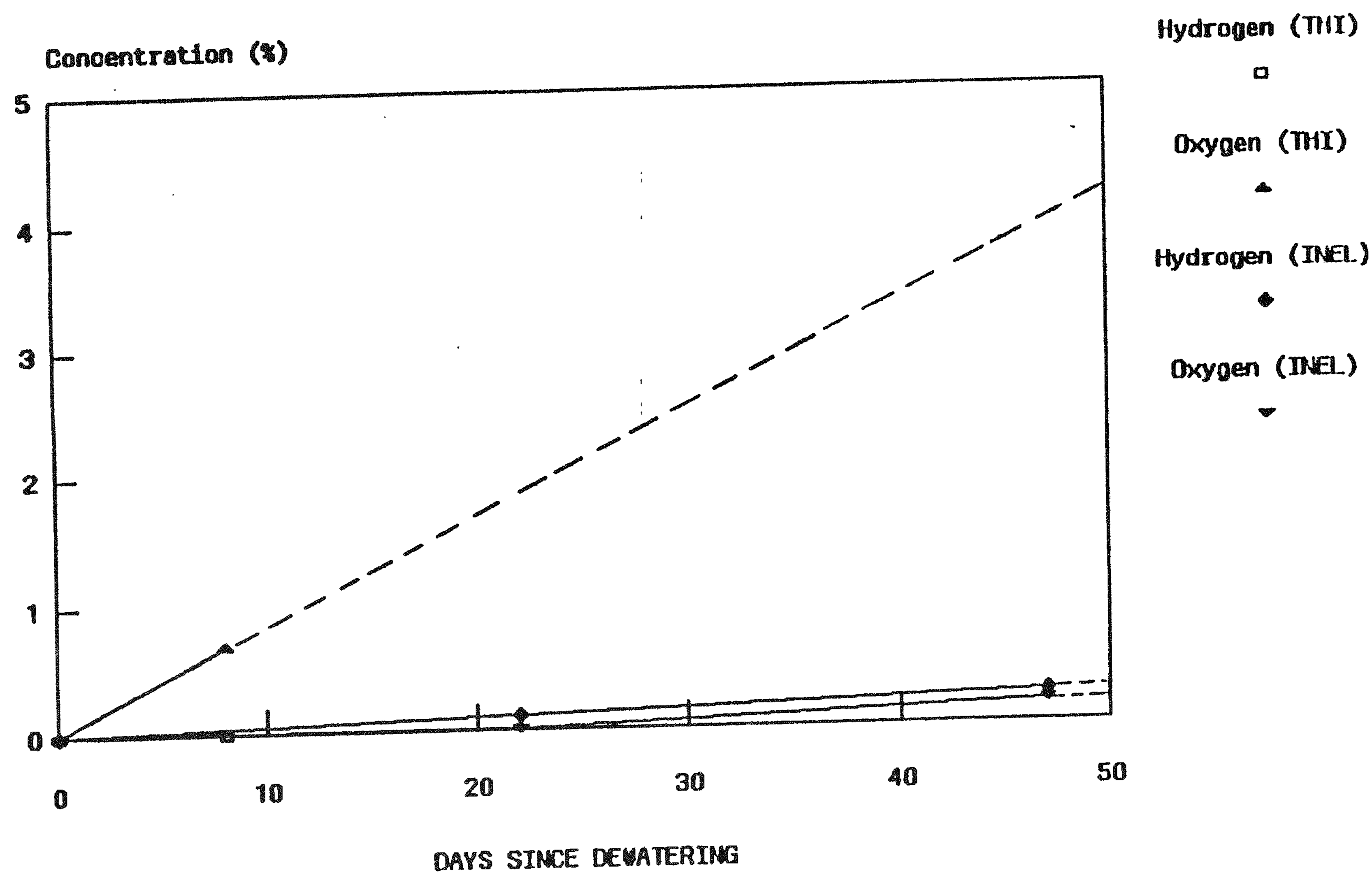
HYDROGEN / OXYGEN GENERATION

D-207



HYDROGEN / OXYGEN GENERATION

D-267



Appendix L

Government Investigations

Appendix L.1

Executive Summary of GAO Report
Shipping Damaged Fuel from Three-Mile Island to Idaho

Appendix L.2

Federal Railroad Administration Report on the February 7, 1988, Train of Reactor Debris from Three-Mile Island, Pennsylvania

Appendix L.3

Executive Summary of DOT Report
Review of the Selection of the Rail Route for Shipping Three–Mile Island Debris

Appendix L.4

Responses to Sierra Club Allegations

Appendix L.1

Executive Summary of GAO Report
Shipping Damaged Fuel from Three-Mile Island to Idaho

United States General Accounting Office

GAO

Report to Congressional Requesters

August 1987

NUCLEAR WASTE

Shipping Damaged Fuel From Three Mile Island to Idaho

GAO/RCED-87-123

Executive Summary

Purpose

The March 1979 accident at Three Mile Island (TMI) severely damaged the reactor's nuclear fuel and produced about 150 tons of highly radioactive debris. Efforts are underway to remove and transport this material to a government research facility in Idaho for further study.

Representatives William Clay, Richard Gephardt, Alan Wheat, and Robert Young requested GAO to report on the

- reasons why the debris is being shipped to Idaho;
- safety standards used for the shipments;
- testing of the transportation containers;
- criteria used to select the shipping route, because of concerns from the July 1986 rail accident in Miamisburg, Ohio, involving fire and hazardous cargo; and
- emergency planning along the route.

Background

One year after the accident, the Department of Energy (DOE); the Nuclear Regulatory Commission (NRC); the General Public Utilities Company (GPU), which owns and operates TMI; and the Electric Power Research Institute agreed to conduct research on the damaged fuel. The research objective is to obtain information that could improve the operation and safety of all commercial reactors. In March 1981 NRC issued an environmental impact statement which stated that the debris from the accident and subsequent cleanup should be removed from TMI because the site is not geologically suitable for the long-term storage of radioactive materials. A March 1982 memorandum of understanding between NRC and DOE stipulated that the debris would be shipped to DOE's Idaho National Engineering Laboratory for research and temporary storage.

According to DOE, between 20 and 40 train shipments over a 2-1/2 year period will be required to transport the material to Idaho. The first shipment was made on July 20, 1986. After the second shipment, a series of reactor defueling problems, such as clogged debris containers, occurred which temporarily halted the shipments. Corrective modifications were made and shipments resumed on December 14, 1986.

Results in Brief

DOE's program is designed to remove the damaged nuclear fuel from TMI and to perform research that may benefit all commercial nuclear power plants. GAO found that:

- DOE decided to ship the damaged nuclear fuel to Idaho Falls because of its facilities and radiological research expertise;
- the shipping containers were designed and tested, and independently reviewed by NRC, to ensure that radioactivity would not escape during any credible accident;
- the criteria for route selection was the best quality track, shortest distance, and avoidance of large population centers; and
- the emergency plans for the TMI shipments are the same as other hazardous cargo, with modifications to accommodate damaged nuclear fuel.

Principal Findings

Program Purpose

According to DOE, its Idaho facility is best suited, due to its unique equipment and personnel expertise, to perform research on the highly radioactive debris that was produced by the TMI accident. The research will provide insight into methods for large-scale decontamination of plant systems and equipment, processing and disposing of the radioactive wastes produced by an accident, and assessing the effects of an accident on the reactor vessel and other important components.

Equipment Design

The transportation equipment was designed and manufactured to safely accommodate the unique characteristics of the damaged fuel. The shipping program has been coordinated among DOE, NRC, GPU, the Federal Railroad Administration (FRA), affected states, and the railroads. Efforts have been taken to assure that appropriate margins of safety exist in all aspects of the program such as engineering and construction standards for the transportation equipment and repeated inspections of the trains and railbeds.

Container Testing

Prior to certification of the damaged fuel containers, NRC and the contractors worked over a 3-year period to develop the shipping package. When compared with containers used to transport undamaged spent nuclear fuel, the TMI containers are designed to provide greater protection against the escape of radioactivity. Destructive tests were performed on scale- and full-size models of the containers, and the results were measured against computer predictions. The containers met the predicted results and passed the tests. In addition, NRC performed an independent safety review which considered the shipping cask design and test results. DOE and NRC are satisfied that the containers will protect against the escape of radioactivity and were not able to identify any credible accident that would breach them.

Route Selection

The route for the shipments was selected by DOE following consultation with FRA, NRC, and the railroads; route study assistance was provided by Oak Ridge National Laboratory and a private consultant. The criteria governing route selection was high quality track, avoidance of population densities, and the shortest, most direct route.

Miamisburg Accident

In July 1986 a rail accident involving hazardous materials and fire occurred in Miamisburg, Ohio. Some residents had to evacuate the area. The accident, however, did not occur on the route used for the TMI shipments. According to DOE officials, the Miamisburg accident did not demonstrate the need to change the route used for the TMI shipments because, in their opinion, the shipping cask would have successfully withstood the accident.

Emergency Planning

In the event of a hazardous materials accident, the rail carrier, local affected community, and the state are primarily responsible for initiating and monitoring recovery operations. The federal government plans to supplement local efforts, if needed, with assistance and support. The emergency plans for the TMI shipments are the same as those used for accidents involving other hazardous cargo, with modifications such as special emergency response teams to accommodate the unique characteristics of the damaged nuclear fuel.

Recommendations

Because the objective of this report was to provide information on the TMI shipments, GAO is making no recommendations.

Agency Comments

GAO obtained comments on a draft of this report from DOE and other federal, state, and private agencies and organizations involved with the damaged fuel shipping program. Although various suggestions were made for improving technical aspects of the report, commentors generally agreed that the report is an accurate and comprehensive account of the program.

Appendix L.2

Federal Railroad Administration Report on the February 7, 1988, Train of Reactor Debris from Three-Mile Island, Pennsylvania

Federal Railroad Administration

REPORT

on the
February 7, 1988 Train of
Reactor Debris from Three Mile Island, Pennsylvania

BACKGROUND:

This report summarizes a Federal Railroad Administration investigation of an incident of incorrect placarding -- a violation of the Hazardous Materials Regulations -- on the fourteenth movement of reactor debris from Three Mile Island, Pennsylvania.

As part of the clean up following the 1979 nuclear power plant accident at Three Mile Island, Pennsylvania, radioactive debris from the core of the reactor is being moved by railroad from TMI to a Department of Energy facility in Idaho Falls, Idaho. The shipments started on July 20, 1986; fourteen shipments have been completed to date.

The reactor core debris consists of approximately 150 tons of radioactive fuel and internal pieces of the reactor that blended with the fuel during a partial meltdown. As core debris is removed from the reactor, it is placed into a canister. Several canisters (as many as seven) are then placed into a reusable shipping cask which is loaded on a rail flat car. The casks are designed to hold about 10 tons of radioactive cargo, but, because of protective shielding and other safety devices, they have an empty weight of nearly 80 tons and only one cask is loaded on each flat car.

The shipments are handled in special train service (the cask cars do not become part of regular freight train consists) from TMI to Idaho, moving first by the Consolidated Rail Corporation to East St. Louis, Illinois and then by Union Pacific to destination.

PREVIOUS SAFETY HISTORY:

Twelve of the first thirteen shipments reached Idaho without incident. Shipment number seven, which departed TMI on March 22, 1987, struck an automobile at a grade crossing in St. Louis, Missouri. The accident happened at the Barron Street crossing, protected by flashing lights and a bell, when the driver of an automobile elected to ignore the bells and lights and proceeded into the path of the oncoming train. Once on the tracks, he saw the locomotive headlight and attempted to reverse his vehicle. The train struck the left front of the car but did not injure the driver. Investigation proved that the grade crossing warning device was operating properly at the time of the accident and that the train was moving at the proper speed. The driver of the automobile was cited for failure to obey Missouri State Law 304,035. For further details see FRA accident investigation report number 53-87.

INCORRECT PLACARDING ON THE FEBRUARY 7, 1988 TRAIN:

The Movement:

The most recent movement of reactor core debris (number fourteen) left TMI via Conrail on February 7, 1988, and arrived in East St. Louis, Illinois without incident. When the train, now under control of a Union Pacific crew, departed for Idaho, an improperly placarded covered hopper car was in the consist between the locomotive and the first cask car. This is a violation of the DOT Hazardous Materials Regulations.

The details of this incident were the subject of an FRA investigation and are summarized in this report.

To gather information, FRA interviewed the Union Pacific train crew, supervisory personnel for Union Pacific and at the East St. Louis trainyard, FRA employees, and public safety officials. The records of the violating car were reviewed and plant inspections were performed both where this car had been loaded and where it had last been unloaded.

FRA's investigation disclosed the following:

- The train arrived in East St. Louis, Illinois at 7:00 am and the yard crew removed the Conrail locomotive, the head and rear buffer cars, and the caboose. Union Pacific locomotive 2473 was added, together with covered hopper MP 710380, at the front of the train and empty gondola MP 6437932 and caboose MP 13710 were added to the rear. The train departed at 7:51 am.

- The head buffer car, MP 710380, was substituted when the original car provided was inspected and part of the brake system was found near the limits of servicable wear. The normal pattern of the TMI trains is to have gondola cars loaded with track ballast as the buffer cars because their loaded weight acts as a buffer to protect the TMI casks, while their lower profile allows clearance for observation by the train crew.

- MP 710380, although loaded with lime (not a hazardous material) by Marble Head Lime, Thorton, Illinois, on February 5, 1988, was placarded on all four sides with FLAMMABLE SOLID, DANGEROUS WHEN WET placards bearing identification number 1402. Shipping documents for this car correctly identified its contents, as did shipment data in the Union Pacific's computer. We are convinced that the train crew knew the car contained lime, not a hazardous material.

- While numerous public officials were present in the East St. Louis yard, few had sufficient familiarity with the hazardous materials regulations to notice the misplacarding or understand its implications. Those present included two representatives from the Missouri State Health Department, a St. Louis County Health Department Official, an FRA Motive Power & Equipment Inspector (a discipline not involving hazardous materials enforcement), and a group of St. Louis City officials including the Fire Marshall, the Director of Disaster, two people from the Health Department, and two police officers. However, three individuals did notice the placards, and failed to take any action to either stop the movement or notify federal officials:

    - The Union Pacific Road Foreman verified the non-hazardous contents of the car after noticing the placards.

    - The brakeman noticed a placard, but noted that it was "half torn off" and "looked like it had been on the car for ages."

    - The St. Louis Fire Marshall noticed the placards on MP 710380 before it was coupled into the train and used his guidebook to look up identification code 1402. After the covered hopper was coupled to the cask cars, he approached a person he assumed was a railroad official, but did not pursue the matter futher when he was told that the individual did not know the contents of the car or whether it was loaded or empty.

- The Union Pacific Manager of Terminal Operations was in a yard tower when he noticed the TMI train crossing the bridge from Illinois to Missouri; he further noticed that the lead buffer car was a covered hopper instead of the originally furnished gondola. He called the East St. Louis yard superintendent and was told about the need for mechanical adjustment on the gondola and that train management personnel in Omaha had given permission to use MP 710380.

- In response to a telephone call from "an unknown individual" to Union Pacific headquarters in Omaha, the train was stopped at Rawlins, Wyoming at 3:46 pm on February 10, 1988, where a Road Foreman observed placards on each end and both sides (two placards were on one side). Despite his opinion that the placards were partially scraped off and "not readily visible," he directed that they be painted over. (The placards had a self-adhesive backing and would not pull off.)

- The train departed Rawlins at 3:55 pm and continued to its destination without further incident.

The Nature of the Violations:

Placards are an important part of the Department of Transportation's hazard information system. Together with shipping papers, placards identify the hazards of commodities carried in rail cars. In the event of an emergency, the placard is often the first indication to emergency response forces that dangerous commodities are involved.

Physically, placards are diamond shaped and slightly more than 10 inches along each side. The color of the placard, its identification number, and "pictograph" in the upper quadrant, all combine to indicate the kind of hazard posed by the commodity involved. The placard on MP 710380 carried identification number 1402 (listed in the DOT Emergency Response Guidebook for calcium carbide), but even if the number had been obscured, the DANGEROUS WHEN WET indicator (a "W" with a slash through it) would warn firefighters not to use their most common fire extinguishing agent.

The DOT Hazardous Materials Regulations state both when placards must be used and when they are prohibited. This incident is a good example of the latter. Because placards are intended to warn of dangers, their warning would be diluted if they were permitted on non-dangerous loads. Moreover, in the case at hand, had the train carrying the fourteenth movement of TMI reactor debris been in an accident, and a fire developed, emergency responders seeing the FLAMMABLE SOLID, DANGEROUS WHEN WET placards on the covered hopper might have delayed using water to extinguish the fire and cool the casks.

Violations of the Regulations:

Both railroads involved, the Union Pacific and the Alton & Southern (the railroad which performed switching service in East St. Louis), and the Marble Head Lime company appear to have violated multiple sections of the DOT's Hazardous Materials Regulations in this incident. Pending enforcement review by the FRA Office of Chief Counsel, the information gathered in the preparation of this report points to the following violations:

171.2 General Requirements
(b) No person may transport a hazardous material in commerce unless that material is handled and transported in accordance with this subchapter ....

This section appears to have been violated by both railroads and the shipper.

172.334 Identification numbers; prohibited display
(b) No person may display an identification number on a placard . . . unless --
(1) The identification number is specified for the material in 172.101 . . .;
(2) . . . and any placard used for display of the identification number corresponds to the hazard class of the material . . .;
(3) . . . the . . . transport vehicle on which the number is displayed contains the hazardous material associated with that identification number . . ..

This section appears to have been violated by the shipper.

172.502 Prohibited packaging
(a) Except as provided in paragraph (c) of this section, no person may affix or display on a transport vehicle . . . any placard described in this subpart unless:
(1) The material being transported is a hazardous material, and
(2) The placard represents a hazard of the material being offered or transported.

This section appears to have been violated by the shipper.

173.1 Purpose and scope
(b) A shipment that is not prepared for shipment in accordance with this subchapter may not be offered for transportation by air, highway, rail, or water.

This section appears to have been violated by the shipper.

173.28 Reuse of packagings (containers)
(d) Packagings previously used for any hazardous material must have the old markings . . . thoroughly removed or obliterated before being used for other materials.

This section appears to have been violated by the shipper.

174.7 Responsibility for compliance
Unless this subchapter specifically provides that another person is to perform a particular duty, each carrier, including a connecting carrier, shall perform the duties specified and comply with each applicable requirement of this part, and shall instruct his employees in relation thereto.

This section appears to have been violated by both railroads.

174.8 Inspection
(b) At any point where a train is required to be inspected, each loaded placarded car and each rail car immediately adjacent thereto must be inspected. The cars may continue in transit only when the inspection indicates that the cars are in safe condition for transportation. . . . The inspection of a rail car other than a tank car . . . must include a visual inspection for obvious defects . . . and to determine whether all required placards are in place and conform to the information given on the train consist or other shipping document . . ..

This section appears to have been violated by both railroads.

174.59 Marking and placarding of rail cars
No person may transport a rail car carrying hazardous materials unless it is marked and placarded as required by this subchapter. Placards and car certificates lost in transit must be replaced at the next inspection point, and those not required must be removed at the next terminal where the train is classified.

This sections appears to have been violated by both railroads.

174.89 Removal of placards and car certificates after unloading
When lading requiring placards or car certificates is removed from a rail car, other than a tank car, each placard and car certificate must be removed by the person unloading the car.

This section appears to have been violated by the shipper, although the more direct violation would be against the company last unloading calcium carbide from the car.

174.89 Position in train of cars placarded "RADIOACTIVE"
In a moving or standing train, a car placarded RADIOACTIVE may not be placed next to any other loaded, placarded car (other than one placarded COMBUSTIBLE), an engine, occupied caboose, or carload of undeveloped film. Cars placarded RADIOACTIVE may be placed next to each other.

This sections appears to have been violated by both railroads.

RECOMMENDATIONS

Based on its investigation of this incident, and in addition to correcting the violations set out above for future moves, FRA makes the following recommendations:

1. Buffer cars should be permanently assigned to the TMI train and should remain with the train during the whole move. This will eliminate switching at the Conrail/Union Pacific interchange.

2. Conrail power and caboose should be replaced with Union Pacific power and caboose at Avon Yard in Indianapolis, Indiana, where additional layover time is scheduled for monitoring radioactivity levels. This will allow all necessary inspections to be performed without time pressure.

3. With the elimination of switching at East St. Louis, consideration should be given to changing the interchange to eliminate handling by the Alton & Southern Railway. This will mean that only Conrail and Union Pacific crews operate the train.

4. Federal Railroad Administration Régional Offices will ensure that inspectors trained in hazardous materials regulations are present at all interchange sites during TMI movements. This will effectively eliminate the possibility that the basic violation which occured could go undetected.

5. The Union Pacific and Alton & Southern Railroads should provide or renew basic training in the hazardous materials regulations for officers and train crews involved in these movements. This would have alerted the train crews who operated, and the officers who saw and traveled on this train between East St. Louis and Rawlins, Wyoming, to two basic violations: the presence of a placarded rail car next to a car placarded RADIOACTIVE and the discrepancy between the shipping papers for MP 710380 and the fact that it was placarded for calcium carbide.

6. The Fire Marshall's office of St. Louis should have notified the Union Pacific and/or Federal Railroad Administration officials about the presence of a placarded car in the TMI train before it left the yard in East St. Louis or as soon thereafter as practical. This would have enabled effective action to be taken immediately. It is important for state, local, Federal, and carrier officials to establish clearly defined lines of communication on matters relevant to these movements; it is equally essential that parties concerned about any aspect of the movements communicate those concerns immediately both to carrier officials and to Federal authorities.

7. Marble Head Lime should provide its employees with a program of remedial instruction on the content and implementation of DOT hazardous materials regulations. This will ensure that non-hazardous materials are not shipped in placarded cars.

Appendix L.3

Executive Summary of DOT Report
Review of the Selection of the Rail Route for Shipping Three-Mile Island Debris

SS-42-U1.1-57(r)

REVIEW OF THE SELECTION OF THE RAIL ROUTE FOR SHIPPING THREE MILE ISLAND DEBRIS

November 1989

Prepared by

ECONOMIC ANALYSIS DIVISION
TRANSPORTATION SYSTEMS CENTER
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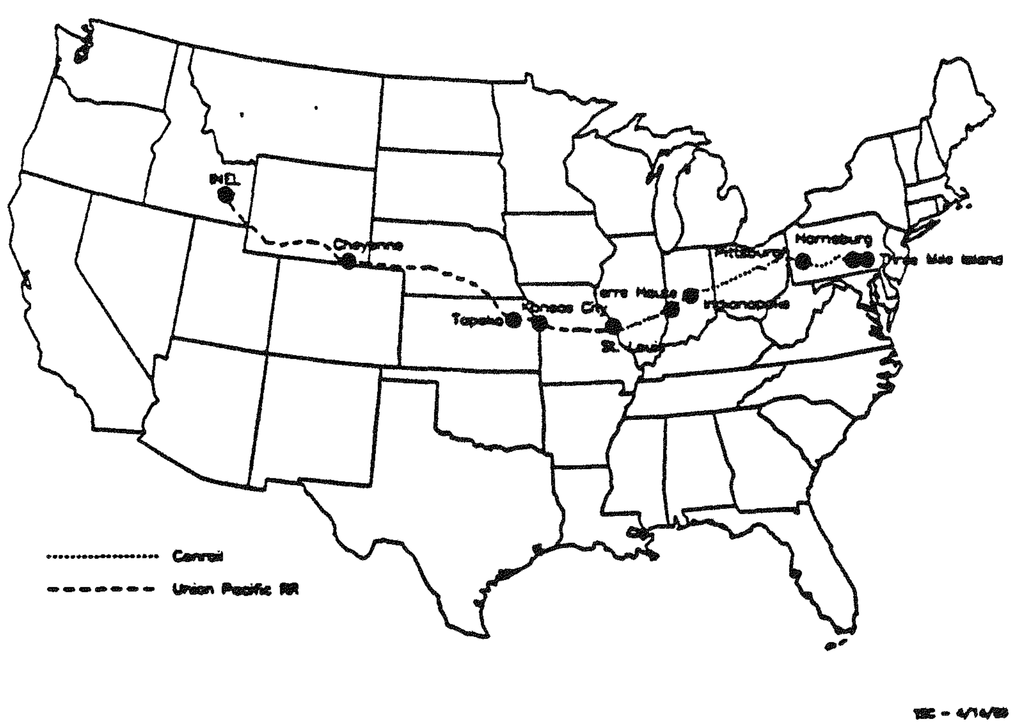
U.S. DEPARTMENT OF TRANSPORTATION

BACKGROUND

The U.S. Department of Energy (DOE) is in the process of shipping debris from the failed nuclear reactor at Three Mile Island (TMI) near Harrisburg, Pennsylvania, to the Idaho National Engineering Laboratory (INEL), a research facility near Idaho Falls, Idaho. About 150 tons of radioactive material are being transported in specially fabricated casks, designed to withstand the forces of severe accidents and certified by the Nuclear Regulatory Commission (NRC) to meet federal safety standards. About 40 caskloads in all will have been shipped over a 2400-mile rail route over a period of several years. The route, shown in Exhibit 1, traverses several large metropolitan areas including Pittsburgh, Indianapolis, St. Louis, and Kansas City. It was selected by DOE after more than six months of deliberation. The first shipment left Three Mile Island (TMI) on July 20, 1986.

DOE encountered opposition to the route, principally in St. Louis but also in other large cities along the route. For the first 18 months of the campaign, DOE responded to such concerns on a case by case basis. DOE assured the public that the shipments were safe, based on the integrity of the casks and a comprehensive and thorough evaluation of routes made by DOE.

EXHIBIT 1. CURRENT RAIL ROUTE FROM THREE MILE ISLAND TO INEL



Current operating practices and federal regulations make the shipment of high level waste acceptable from a safety perspective. However, the public, influenced by the nature of the material, apparently perceives a risk higher than that based on technical considerations. This perceived risk focuses public concerns on the route selection process.

After 13 shipments had been completed, an operational incident in the St. Louis area prompted Senator John C. Danforth of Missouri to request that the DOE ask the U.S. Department of Transportation (DOT) to conduct an independent assessment of the TMI route. Secretary of Energy John S. Herrington formally requested the DOT study in a letter to Secretary of Transportation James H. Burnley, dated April 29, 1988. Responsibility for the study was assigned to the Office of Hazardous Materials Transportation (OHMT) of the Research and Special Programs Administration (RSPA). OHMT tasked the Transportation Systems Center (TSC), also part of RSPA, to conduct the DOT TMI study.

In Secretary Herrington's letter, the DOE asked DOT to "assess the current route in light of... [the DOE]...selection criteria." The DOT directed TSC to focus the evaluation on two aspects of the routing decision. TSC was to assess the route selection process and to evaluate the route chosen by DOE. Both aspects required an understanding of the selection criteria, as mentioned in Secretary Herrington's request. Thus, TSC assessed the degree to which the stated criteria were consistently defined and prioritized and examined the influence of the criteria upon the route choice. Alternative routing options were not explored or evaluated.

The shipping cask's contribution to safety was taken as a given in the TSC assessment. The study's focus was exclusively on the route. The safety of the cask has already been addressed by other agencies. The NRC has certified that the TMI cask meets safety standards. The NRC also determined that the quality assurance program for the operational use of the cask is adequate. The Office of Technology Assessment's (OTA) recently completed report (1986), "Transportation of Hazardous Materials," states that "NRC performance standards...provide for a very high level of public protection--much greater than that afforded in any other current hazardous materials shipping activity." The OTA states further that "the probability of an accident severe enough to cause extensive damage to public health and the environment caused by a radiological release from a properly constructed cask is extremely remote."

For this assessment, TSC reconstructed the process by which DOE chose the current route. TSC staff reviewed all written correspondence, directives and reports made available by DOE in response to DOT requests for documentation on the selection process. TSC also interviewed DOE and contractor personnel involved in the route determination. To evaluate the use of routing models by DOE consultants, TSC reviewed the technical aspects of the models, such as the nature of inputs, outputs, assumptions, data and algorithms, with those who developed and operated the models. TSC also exercised one of the models (Interline, developed by Oak Ridge National Laboratory), exploring its behavior with respect to various inputs and program options. To assess the performance of the current route, TSC both analyzed the original consultants' reports and made independent calculations from other data sources. Performance was measured in terms of the selection criteria alone and not relative to any alternative routes.

FINDINGS

With respect to the route selected, TSC finds it to be a reasonable choice having the following attributes related to the DOE criteria.

1. The quality of the track is high (97% is mainline trackage), which accounts for the historically low accident rate experienced by rail shipments along the route and for the minimal transit time for the TMI shipments (4-5 days). Track inspectors from the Federal Railroad Administration (FRA) inspected the entire length of the TMI route and reported the condition of the track to DOE before the first shipment. FRA inspectors repeat this procedure at least every six months.

2. The near minimal distance and number of switching delays also contribute to the short transit time. Short transit time reduces non-incident radiation exposure of transportation workers and the public. It should be noted that actual radiation readings at the cask surface have been about 2-3% of the amount allowed by regulation.

3. With respect to the safety records of the selected carriers in handling hazardous materials, Conrail's performance would be judged somewhat below the industry norm and Union Pacific's appears to be significantly better than that of the industry as a whole.

4. The involvement of a minimal number of rail carriers (i.e., the originating and terminating railroads) reduces the amount of switching in rail yards, typically the location of a large percentage of rail accidents.

5. Population exposure is over twice that of a minimum population route identified by a DOE consultant.

With respect to the route selection process, TSC finds the following.

1. DOE relied upon independent technical analyses and NRC certification that the cask would provide an acceptable level of public safety and consequently handled route selection in a manner similar to that for routine DOE shipments. DOE relied on the expertise of its field office traffic manager and the railroad representatives who chose the route without conducting a formal risk assessment or a routing analysis that explicitly considered the hazardous nature of the cargo. The field traffic manager was responsible for making the final choice.

2. During the course of planning the shipping campaign, DOE did not have well developed guidelines for route selection; the route selection process and the rationale for choosing the current route were not documented. Routing criteria cited by DOE at various points prior to or during the campaign fell into three general categories: safety, "schedular" efficiency, and cost effectiveness. Since the initiation of this study, DOE has issued written guidelines for traffic managers to use in route selection.

3. The DOT does not have regulations that specifically address rail routing of any hazardous material. In part, DOE explained the choice of routes by stating that the general DOT guideline for routing radioactive materials is to minimize time in transit. This apparently refers to existing DOT regulations pertaining to highway transportation. The routing of substantial quantities of radioactive material by highway is regulated by 49 CFR 177.825(b), which requires carriers to use "preferred" routes. In promulgating that rule, the DOT determined that use of Interstate highways would enhance public safety since those routes generally had lower accident rates than other highways. Consequently, "preferred" routes are Interstates and/or routes designated by states that adequately consider overall risk to the public. Selection of the final route from the set of "preferred" routes is made by the carrier to reduce time in transit.

4. Population exposure, i.e., wayside population, was not a significant determining factor in the route selection, given DOE's confidence in the safety afforded by the cask. The DOE routing guidelines

referred to in item 2 above do not include wayside population.

5. The rail routing models used by DOE consultants were constructed to estimate how railroads would route routine shipments. The route selection for hazardous materials shipments characteristically involves multiple objectives or criteria, as is the case with the DOE criteria. The models referred to were not designed to identify optimal routes that satisfy multiple objectives or criteria.

APPENDIX L.4

Responses to Sierra Club Allegations

EG&G Idaho, Inc
PO Box 88, Middletown, PA 17057

March 17, 1987

DISTRIBUTION

RESPONSES TO THE SIERRA CLUB'S "ANALYSIS OF MODEL 125-B TMI SHIPPING CASK" - LJB-25-87

Ref: "Analysis of Model 125-B TMI Shipping Cask", Marvin Resnikoff, Sierra Club Radioactive Waste Campaign, New York, N. Y., July 8, 1986

Dear Sir or Madam:

Enclosed please find a copy of the TMI-2 Program response to the referenced thermal analysis of the Model 125-B rail cask by physicist Marvin Resnikoff. Mr. Resnikoff is a staff scientist for the Radioactive Waste Campaign. His analysis makes several allegations but focuses on recommendations for redesign of the cask system to provide higher margins of safety related to fire accident environments. The response addresses each of the allegations and discounts the need for redesign or rework of the rail cask.

If you have questions or comments relative to the enclosed material, please call at (717) 948-1014 or FTS number 590-1014.

Very truly yours,

L. J. Ball/ml

L. J. Ball, Manager
TMI Fuel and Abnormal Waste
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RESPONSES TO THE ALLEGATIONS BY THE SIERRA CLUB RADIOACTIVE WASTE CAMPAIGN IN THEIR "ANALYSIS OF MODEL 125-B TMI SHIPPING CASK"

ABSTRACT

A July 8, 1986 Newsletter published by the Sierra Club Radioactive Waste Campaign presented a series of allegations which principally claimed that the Model 125-B cask used for transport of Three Mile Island Unit 2 spent fuel debris, as designed and fabricated, may not withstand a hot and long duration fire resulting from a transportation accident. This document is a response to the allegations and explains why the Model 125-B cask will survive the hypothetical fire accident specified in the federal regulations. The thermal environment which must be considered to demonstrate compliance with those regulations is a more severe fire accident than rail transport casks could reasonably be expected to encounter. Additional margins of safety intrinsic in the Model 125-B cask would ensure the safety of the public in a fire scenario even more severe than the regulatory fire conditions.

INTRODUCTION

On July 8, 1986, the Sierra Club Radioactive Waste Campaign (Sierra Club) published a Newsletter with a series of allegations which principally claimed that the Model 125-B cask used for transport of Three Mile Island Unit 2 (TMI-2) spent fuel debris, as designed and fabricated, may not withstand a hot and long duration fire resulting from a transportation accident. The allegations, called an "Analysis of the Model 125-B TMI Shipping Cask," are based on the argument that the fire accident conditions specified by the U.S. Nuclear Regulatory Commission (NRC) in federal regulations for certification of such shipping casks are not as severe as fires which have occurred or could occur. Design requirements for Type B casks, which include spent fuel shipping casks, are imposed to ensure these radioactive material shipping packages are designed to be accident-resistant before being approved for use by the NRC.

As a point of reference, allegations on the purported inadequacy of the design requirements for spent nuclear fuel shipping casks also were made in January 1982. Responses to those prior allegations were prepared by the Transportation Technology Center at Sandia National Laboratories. Those responses, "Analyses of Recent Council on Economic Priorities Newsletter," (Ref a) and "Transporting Spent Reactor Fuel, Allegations and Responses," (Ref b), are useful sources of information about the safety of spent fuel transport. Information from those two documents has been utilized extensively below.

The current Sierra Club newsletter assumes, in a recommendation for redesign of the Model 125-B cask, that an increase in the fire temperature and duration used in the thermal analysis of the Model 125-B cask would lead to replacement of certain cask components. Also recommended is a change in operating procedures which would remove water completely from the canister payload. Implementing these recommendations is not justified due to the adequacy of the current design requirements for Type B casks and, the demonstrated ability of the Model 125-B cask to survive the sequence of hypothetical accident conditions in the federal regulations. Those regulations already impose a design requirement for surviving a severe thermal environment. This paper, prepared at the request of the U.S. Department of Energy, provides responses to the allegations in the

Newsletter and explains, in general, how safe the Model 125-B cask would be if in a fire resulting from a transportation accident. A complete and technical description of the Model 125-B cask and its behavior in hypothetical transportation accidents is available in the Safety Analysis Report for the Model 125-B cask (Ref. c).

RESPONSES TO SIERRA CLUB NEWSLETTER ALLEGATIONS

The following responses to the Sierra Club allegations use published information and publicly available documents to address the concerns expressed in the Newsletter. The complete Sierra Club newsletter is reproduced in Appendix A as it was published. The format used below provides the original text from the Newsletter on the left-hand side of the page and the response to the allegations on the right.

Sierra Club Newsletter

Analysis of the Model 125-B
TMI Shipping Cask

The Model 125-B shipping cask, designed by Nuclear Packaging, Inc. to transport radioactive rubble from the TMI reactor, is the first commercial rail cask to be licensed by the Nuclear Regulatory Commission since 1972. It is also the swiftest and most incomplete licensing since the days of the old Atomic Energy Commission. Because of the speed with which this application was processed, the customary care with which the Transportation Certification Branch of the Nuclear Regulatory Commission evaluates these applications, was missing here.

Responses

The Model 125-B cask for shipment of TMI-2 core debris is a spent nuclear fuel rail cask approved for use by the Transportation Certification Branch of the U.S. Nuclear Regulatory Commission (NRC). Approval for use was granted only after satisfactory resolution of NRC questions following a thorough and complete review of the safety analyses in the application and the supporting drop test results. The review of such shipping casks by NRC involves the same evaluation of compliance with safety requirements for either truck or rail type casks. The last certification of such a cask by the NRC was in 1983 and, while it was a truck-type cask, there is no basis for a concern that the last rail-type cask was licensed in 1972. Likewise, the speed was not unusually swift since both the Model 125-B cask and the recent truck cask were approved for use in less than two years. The approval of the Model 125-B cask rests entirely on the completeness of the application and the compliance with safety requirements which the application demonstrates. The application was in fact subjected to one of the most intensive reviews in the history of radioactive materials transport and independent reviews were performed by Department of Energy (DOE) national laboratories as well as by GPU Nuclear and its contractors. Only after preparation of the Safety Analysis Report (SAR) for the Model 125-B cask and completion of the many supporting reviews was the application submitted to NRC for independent evaluation. From the first cask certification meeting with NRC on August 29, 1984 until the Certificate of Compliance was issued on April 11, 1986, more than 19 months and many person-years of effort were expended. A brief chronology and explanation of the certification process are provided in Appendix B.

This critique centers on the thermal analysis. Impact and crush forces are not considered here. Material will not be shipped in the Model 125-B container "dry". The fuel

Although the TMI-2 fuel debris is no longer sealed in fuel rods, the condition of the material is accounted for in the double containment design of the Model 125-B cask. There are pellets would be placed in containers, seven to a cask, the total package, cask, containers, and fuel weighing approximately 90 tons. Each container will hold considerable water. In the case of a long-duration fire, pressures can build within the containers and the cask, causing the safety valve, or rupture disk, to fail. Unlike fuel in fuel assemblies, which are contained within fuel rods, the fission products could directly mix with steam and be released from the cask.

three independent levels of protection that must be breached before a release of fuel material from the Model 125-B cask could occur. Also, although a canister has the capacity to hold a considerable amount of water, the canisters are dewatered to a drip-dry condition by gas displacement before shipment and only a small amount of water remains and is present in canisters during shipment. A description of the cask and the preparation of the canisters for shipment is provided in Appendix C. The Model 125-B cask is approved for use only after assuming the cask is engulfed in a severe fire during a hypothetical transportation accident. Fire conditions resulting from transportation accidents that would be more severe than current regulatory fire conditions are unlikely; therefore, assuming worse fire conditions is unreasonable.

Thermal Analysis

Being a massive container, a large amount of heat input is required to heat the contents of the cask above the boiling point. According to the "125-B Shipping Cask Safety Analysis Report", under the standard IAEA hypothetical accident conditions, 1/2 hour fire at 1475°F, the canister shell would heat only to 180°F.

The amount of heat needed to raise the temperatures of the cask's outer containment vessel, inner containment vessel and canisters is so large that it is unreasonable to assume a fire would occur which would be long enough and hot enough to cause a failure releasing any of the contents of the Model 125-B cask. The

These hypothetical fire conditions, however, are not the most severe accidents conditions that have been or could be encountered by rail.

hypothetical fire conditions are already a severe thermal environment as explained in Appendix D. The Model 125-B cask has been designed to withstand the hypothetical fire conditions. Moreover, there is enough margin of safety designed into the various components of the cask that much higher temperatures and pressures than those predicted to occur after the hypothetical fire accident conditions would be needed to cause any release of the contents.

A large number of fires have burned hotter and longer than the IAEA standard. A diesel fire, for example, burns at 1850°F. Since the TMI shipments will move on mixed goods trains with a large amount and assortment of combustible material, it is possible to have long duration fires. Hazardous materials and highly flammable materials may prevent firefighters getting close enough to effectively fight a fire. A study completed for the Nuclear Regulatory Commission in 1983 shows that real accidents can easily exceed the design accident conditions. For example,based on a survey of 500 real highway and rail accidents in the U.S. between 1969 and 1981, the NRC

The severity of a fire on an object like the cask cannot be fully described simply in terms of the temperature and duration of the fire. Rather, the integrated heat flux incident upon the object is of concern and is generally proportional to the product of time, temperature, and extent of the fire. Also, the ability of the object, (i.e., the cask) to absorb the energy incident upon it must be considered. The Newsletter's assertion that "A diesel fire, for example, burns at 1850°F," may be true, but a complete description of fire severity is not made by just asserting that some fuels may burn hotter or longer than the regulatory fire conditions.

contractor, REA (1), concluded that the fire test for rail flasks should be a two hour engulfing fire at 1600°F, as compared to the IAEA 30 minute fire at 1475°F. Rail fires have ranged in duration from less than an hour to 169 hours (7 days) in the following fire duration histogram, according to REA, p. H-40.

Fire Duration (Hours)	Number
0 - 9	11
10 - 19	1
20 - 29	1
30 - 39	2
40 - 49	0
50 - 59	2
60 - 69	1
70 - 79	1
80 - 89	0
90 - 99	1
100 - 109	0
110 - 119	0
120 - 129	1
130 - 139	0
140 - 149	0
150 - 159	0
160 - 169	1
Total	22

First, there are not many common industrial materials which are shipped in large enough quantities to fuel a large and long-duration fire and which burn at high temperatures without special burners and/or oxygen supplies. Tests have shown that 1475°F is a realistic radiating temperature, even for fires as hot as 1850°F; that is, while some materials burn at higher temperatures, they do not radiate (transfer heat energy by radiation) at their adiabatic temperatures.

Second, although some fires experienced in actual accident conditions do burn for longer than the regulatory 30-minute fire, these fires may not expose the entire cask surface to a high heat flux for two reasons: longer burning fires either burn at lower temperatures (consuming slower-burning materials such as wood) or are concentrated over several small areas.

Third, if a fire is not of sufficient thickness, the cask can radiate heat back through the flames reducing the severity of the thermal environment to the cask.

The fire duration histogram taken from the REA report on page H-40 is insufficient information to conclude that the NRC regulatory fire conditions in 10CFR71.73 c(3) are inadequate and should be replaced by a two hour duration engulfing fire at 1600°F. In fact, the REA report two pages later, on page H-42, summarizes the data for the accident environment when a large fire occurs as follows:

"Summary. The data described above indicates the distributions for the overall area of coverage and duration of rail fires reasonably well. However, information on fire intensity is not as readily available. Without such information, it is difficult to predict the frequency with which a given package is exposed to severe thermal stresses (e.g., temperatures and heat fluxes) for long periods of time."

A particularly severe highway fire occurred in the Caldecott Tunnel near Oakland, California, April 1982 (2). This highway accident involved a collision between a tanker truck, carrying 8,000 gallons of gasoline, a bus and a stalled car. The ensuing fire burned for 1-3/4 hours, reaching temperatures of 1900°F for at least 20 minutes.

The Caldecott Tunnel fire was indeed a severe fire comparable with the thermal input required in the NRC regulations. Tests conducted on actual spent fuel shipping casks with time-temperature inputs up to six times as high as that required by the regulations did not cause failure of these casks.

Under the real (vs. IAEA hypothetical) fire conditions, the temperature of the canister would easily exceed 212°F. Since the canisters contain water, the pressure

Only a very improbable fire accident would exceed the 10CFR71 (i.e., IAEA) hypothetical fire conditions. While calculations have not been performed to predict the within each canister would likely exceed design conditions releasing steam to the cask cavity. The NRC condition, in the cask Certificate of Compliance, that the cask cavity and inner vessel be dry, makes no sense unless the canisters are dry as well.

severity of a fire at which each of the multiple barriers in the Model 125-B cask would be breached, comparison of the cask temperatures and pressures reached in the regulatory fire with temperatures and pressures which the cask can safely withstand shows the cask components have additional margins of safety and would withstand a fire more severe than the regulatory fire conditions. Beyond even this, the Model 125-B cask has been designed and built to safely relieve overpressurization in the cask's outer and inner containment vessels in a controlled manner through rupture disks. An explanation of the cask's performance in the regulatory fire and remaining safety margins is provided in Appendix E.

Since the rupture disks are set at 300 psig, it is possible for the rupture disks to fail, releasing radioactive steam to the environment. Calculations by GE for the IF-300 cask show that pressure would exceed 300 psig due to the contained water.

The calculations for the IF-300 cask are not relevant to the Model 125-B cask. The contained water in the IF-300 cask is located in the neutron shield which is exterior to the cavity containing the dry spent fuel. The Model 125-B cask is also a dry cask which is substantially free of water, except for a limited amount of residual water in canisters. That amount is accounted for in the Model 125-B cask safety analyses. Thus, the pressure buildup in the two cask containment cavities would be more comparable and much different from pressure increases in the neutron shield tank of the IF-300 in a fire.

Recommendation #1: To prevent the possibility of radioactive steam being released to the environment in a long duration fire, the canisters should be shipped completely dry.

The very low probability of a long-duration fire severe enough to cause a release from the Model 125-B cask justifies the adequacy of the design and the operation with a small quantity of residual water. The remote possibility of a release should be recognized as an unlikely event and not the reason for expenditure of the considerable resources in terms of dollars, time, or radiation exposure to workers needed to implement the recommendation.

Several components of the shipping cask are "thermally-sensitive", including the Neoprene O-rings used to seal the cask (230°F), the BISCO neutron moderators (220°F) and the polyurethane foam overpacks (150°F). In fact, it would be surprising if the foam impact limiters did not shrink solely due to the sun heating the stainless steel skin. While the thermal insulation might not be affected because of the air pockets, the ability to absorb impact, however, would. In their rush to certify the shipping cask, the NRC did not verify whether the impact limiters would be so affected.

The maximum temperatures for various locations in the cask for normal operation and after the regulatory fire accident are included in Appendix E. The "thermally sensitive" materials have predicted temperatures well below the top of their recommended operating range and thus have remaining safety margins even after the regulatory fire. Table E1 of Appendix E lists the maximum temperature of the overpack shell (and therefore of the foam impact limiters) as 135°F based on a conservative calculation of normal (non-accident) conditions. This means that, unless the cask were in a fire, the foam temperature would still be below the maximum recommended operating temperature of 150°F.

Realistically, the foam will not be affected by only atmospheric temperatures. Normal shrinkage occurs when temperatures drop in winter and normal expansion occurs when temperatures rise in the summer. Those changes certainly would not adversely affect the energy absorbing performance of the foam during impact accidents. As shown in the cask SAR, when the foam temperature increases from -20°F, the impact loads on the cask in a hypothetical accident actually decrease. This is because the foam becomes less stiff and absorbs the impact energy over a longer distance of foam crush. The allegation that the foam's "ability to absorb impact" might be detrimentally affected by an increase in foam temperature up to 135°F is clearly not true. In fact, the opposite is true. The variability in foam performance due to changes in temperature or slight variations in foam density is well documented in the SAR for the Model 125-B cask. The NRC had all the needed impact energy absorber information available for review.

The cask contains a thermal shield, a relatively thin stainless

Design of the Model 125-B cask does include a thermal shield around steel skin containing water. The thermal shield protects against neutrons, which is not a problem with low burnup TMI fuel. This thin shield would be immediately ruptured in an accident. Contrary to the NRC analysis, the thermal shield should not be counted on to prevent lead melting and thermal degradation of closure seals and BISCO moderators.

the outer circumference of the outer vessel. The thermal shield consists of an annular air gap, nominally 0.106 inch thick, covered by a 10 gauge (0.134 inch thick) stainless steel cylinder. There is no water associated with the thermal shield; it is a completely passive system. Unlike the neutron shield tank of the IF-300 cask mentioned above, the thermal shield has nothing to do with shielding against neutrons and is included in the design solely for thermal protection of the Model 125-B cask. The air gap serves as conductive insulation and the highly polished outer surface provides reflective insulation. The cask thermal analysis does assume damage to this relatively thin outer stainless steel shield for the fire accident condition. The undamaged portion of the thermal shield remaining is still adequate for protection of the cask components and canisters. See Appendix E for an explanation of the performance of the Model 125-B cask in a fire accident.

The BISCO moderators separate the seven canisters and hold the cask contents subcritical. In a long duration fire, the moderators could melt. If the cask interior was dry, no nuclear reaction would take place.

The inner vessel of the Model 125-B cask utilizes two forms of BISCO neutron absorbing materials, NS-3, a cement-like material containing boron carbide, and NS-4, a high carbon composite material containing boron

However, if following a fire and destruction of the rupture disks, the cask rolled into water, serious consequences could ensue since the TMI fuel is only 10% used. In this case, the cask would cool, water would enter, and a nuclear reaction would begin. Water would then heat up and be expelled, shutting down the reaction. Water would enter and the reaction would restart. This pulsing phenomenon would continue for several years, each time emitting radioactivity. The consequences of this type of admittedly remote accident are sufficiently grave that the NRC should ensure that the cask and containers are absolutely dry so that the rupture disk does not fail. It may be preferable to install pressure relief valves.

carbide. The NS-4 is in the form of long precast rectangular blocks. Support for the seven tubes that hold the canisters is provided by the honeycomb-like structure internal to the inner vessel. The NS-4 blocks provide continuous support between the tubes and the internal support structure. Once welding of the inner vessel was completed, NS-3 material was pumped into the cavities formed by the outside of the tubes and the internal support structure. The NS-3 material filled the internal spaces surrounding the NS-4 blocks and then hardened like concrete. In terms of thermal degradation resistance, the NS-4 material is rated for continuous use at temperatures up to 250°F and is thermally stable at temperatures up to 400°F for short durations. In addition, NS-4 acccounts for only 10% of the total neutron absorbing material and, in a fire, it would be close to the canisters and away from the fire. The NS-3 material is a fire resistant material and, in fact, is recommended for use in vaults as a high temperature criticality control material. Both of the materials are rated for temperatures well in excess of those calculated for the regulatory accident fire conditions and melting of the BISCO materials will not occur even in an extremely severe fire.

Note also that the SAR did consider damage resulting from the hypothetical accident conditions in the analyses for potential nuclear reactions. The cask remains subcritical after these severe conditions and, furthermore, a reduction in density of 50% for the neutron absorbing materials was even considered in the analyses. After very severe accident conditions, the cask contents would not begin a nuclear reaction. The pulsing scenario described in the newsletter is incorrect, particularly in suggesting that after an accident the cask would be left releasing radioactivity "for several years."

Recommendation #2: In agreement with the REA study, the Model 125-B cask should be redesigned to withstand a two hour fire at 1600°F, and be rebuilt. Components which are thermally sensitive should be replaced.

As stated in the REA study, there was not enough information available from the accounts of accidents involving fires to determine whether the severity of the fires were greater than the hypothetical fire accident conditions. The REA study used available data to define more severe limits for the hypothetical accidents than those used in current regulations. However, the REA study did not assign probabilities to these more severe hypothetical accidents. As the severity gets worse the likelihood of occurrence gets smaller. The currently established severity limits in the NRC regulations have been very effective over the three decades of use. No Type B (accident-resistant) package for transporting radioactive materials has ever released the contents because of an accident.

The NRC should also ensure that local emergency personnel are available to handle a fire, thereby preventing long-duration fires. This can only happen if local personnel are prenotified when the shipments are expected to pass through an area. The DOT should ensure that the cask is kept far from flammable materials, not only while in transit, but in the railyard as well. Though the DOT has few inspectors knowledgable about radioactive materials, it is mandated to ensure safe transit.

The principal function of the local emergency personnel would be to isolate the accident scene until assistance arrives. If additional training is desired, the DOE provides funds in conjunction with the Federal Emergency Management Agency (FEMA) to conduct the appropriate training of emergency response personnel in handling off-normal radiological events. In addition, the DOE has on standby Radiological Assistance Program teams (RAP-teams) that are located throughout the country and can be at the site of an incident within hours of the occurrence to assist local authorities.

The DOE procedures require that each state on the route be notified of the shipping campaign. Each state has a "Governor's Designee" who is notified and who is then responsible for informing local officials on a "need-to-know" basis.

Transportation of the TMI-2 core debris complies with the applicable regulations of the U.S. Department of Transportation (DOT), which regulates shipments under the authority of the Hazardous Materials Transportation Act. DOT has established extensive safety regulations for radioactive materials transport including, but not limited to, requirements for inspections, packaging, monitoring, training, security and reporting. Under DOT regulations, the cask must not be located next to other placarded hazardous material or occupied railcars while in transit and must not be in rail yards for extended periods of time (less than 48 hours).

In the more than 31 years of transporting radioactive materials across the United States, an exemplary record of safety has been achieved. Although there is public apprehension about shipping spent fuel, there has never been an injury or death attributable to radiation as a result of an accident involving transportation of radioactive materials.

Since a film describing the Sandia tests on obsolete containers is shown frequently, it is worthwhile comparing its pertinence to the Model 125-B shipping cask. The Sandia cask

The Model 125-B cask would survive the regulatory thermal environment without any releases. The small amount of residual water would be heated but not released as steam had no internal heat source, and was designed to withstand a 1475°F for one hour, rather than 1/2 hour for Model 125-B. The Sandia cask was 90% filled with water. Though the pressure sensors did not operate during the Sandia test, according to a Sandia official, the pressure relief valves opened for about 45 minutes of the 120 minute test, relieving the cask internal pressure, and releasing an unknown amount of water. Sandia failed to measure the amount of water following the fire test. In the case of the Model 125-B cask, the small internal volume of contained water would expand rapidly. Since the Model 125-B cask has no pressure relief valve, the rupture disk would open, and the steam would be released continuously.

from the canister (a pressure vessel). Each canister has an initial pressure of 2 atmospheres of inert gas and a temperature increase to 265°F would be needed to boil water at this pressure. Such a temperature is well above the 180°F maximum predicted temperature for the canisters in the fire accident condition.

The Sandia tests are not specifically relevant to the Model 125-B cask safety and thermal analyses, but provide insight into the behavior of spent fuel shipping casks in general. The allegations are discussed and discounted in references a and b.

Catalytic Recombiner

In one of the great mysteries of the Model 125-B system, almost no information is presented about the catalytic recombiners located within each canister. These devices or materials are designed to recombine hydrogen and oxygen to form water so that H_2 does not build to the point where it explodes. The B&W Canister Appendix has no information on the

Information on the catalysts used in the debris canisters is publically available. The SAR for the Model 125-B cask contains a short description of hydrogen and oxygen generation in Chapter 3, Thermal Analyses and includes in section 3.7, Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris, recombiners. We are therefore mystified how the NRC was able to analyze the safety of the catalytic recombiner, and to specify conditions in the Certificate of Compliance. Under the rush of approving the application, the Certificate Branch neglected to ask for this important information.

GEND-051, as reference 11. See Ref. d below. Control of these gases during transport of radioactive materials has been the subject of much independent research and is a major condition specified in the Certificate of Compliance (COC) issued by the NRC (see page 3, paragraph 8 of COC No. 9200). Gas generation, the performance of catalytic recombiners, and compliance with conditions in the COC are explained in detail in Appendix F.

CONCLUSION

The Sierra Club allegations are another way of asking "How safe is safe enough for the Model 125-B cask in a fire?" The above responses show that the Model 125-B cask was carefully designed to purposely meet or exceed the current regulations. The extra quality in the design, and the extra margins of safety demonstrated to the regulators that the cask design more than meets the current requirements for the safe transport of radioactive material. The DOE chose this approach to ensure no undue delays would occur with obtaining cask approvals and thereby fulfilled a commitment to assist in the cleanup of the TMI-2 accident in a safe and expeditious manner.

REFERENCES

a. Analysis of Recent Council of Economic Priorities Newsletter, SAND82-1250·TTC-0318, R. M. Jefferson, et al., May 1982

b. Transporting Spent Reactor Fuel, Allegations and Responses, SAND82-2778·TTC-0403, R. M. Jefferson, March 1983

c. Safety Analysis Report for the NuPac 125-B Fuel Shipping Cask, NRC Docket No. 71-9200, Rev. 3, July 1986.

d. Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris, GEND-051, J. O. Henrie and J. N. Appel, June 1985.

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ANALYSIS OF MODEL 125-B TMI SHIPPING CASK
by Marvin Resnikoff*

The Model 125-B shipping cask, designed by Nuclear Packaging, Inc to transport radioactive rubble from the TMI reactor, is the first commercial rail cask to be licensed by the Nuclear Regulatory Commission since 1972. It is also the swiftest and most incomplete licensing since the days of the old Atomic Energy Commission. Because of the speed with which this application was processed, the customary care with which the Transportation Certification Branch of the Nuclear Regulatory Commission evaluates these applications, was missing here.

This critique centers on the thermal analysis. Impact and crush forces are not considered here. Material will not be shipped in the Model 125-B container "dry". The fuel pellets would be placed in containers, seven to a cask, the total package, cask, containers and fuel, weighing approximately 90 tons. Each container will hold considerable water. In the case of a long-duration fire, pressures can build within the containers and the cask, causing the safety valve, or rupture disk, to fail. Unlike fuel in fuel assemblies, which are contained within fuel rods, the fission products could directly mix with steam and be released from the cask.

Thermal Analysis

Being a massive container, a large amount of heat input is required to heat the contents of the cask above the boiling point. According to the "125-B Shipping Cask Safety Analysis Report," under the standard IAEA hypothetical accident conditions, 1/2 hour fire at 1475°F, the canister shell would heat only to 180°F. These hypothetical fire conditions, however, are not the most severe accidents conditions that have been or could be encountered by rail.

A large number of fires have burned hotter and longer than the IAEA standard. A diesel fire, for example, burns at 1850°F. Since the TMI shipments will move on mixed goods trains with a large amount and assortment of combustible material, it is possible to have long duration fires. Hazardous materials and highly flammable materials may prevent firefighters from geeting close enough to effectively fight a fire. A study completed for the Nuclear Regulatory Commission in 1983 shows that real accidents can easily exceed the design accident conditions. For example, based on a survey of 500 real highway and rail accidents in the U.S. between 1969 and 1981, the NRC contractor, REA (1), concluded that the fire test for rail flasks should be a two hour engulfing fire at 1600°F, as compared to the IAEA 30 minute fire at 1475°F. Rail fires have ranged in duration from less than an hour to 169 hours (7 days) in the following fire duration histogram, according to REA, p. H-40,

Fire duration (hours)	Number
0 - 9	11
10 - 19	1
20 - 29	1
30 - 39	2
40 - 49	0
50 - 59	2
60 - 69	1
70 - 79	1
80 - 89	0
90 - 99	1
100 - 109	0
110 - 119	0
120 - 129	1
130 - 139	0
140 - 149	0
150 - 159	0
160 - 169	1
Total	22

A particularly severe highway fire occurred in the Caldecott Tunnel near Oakland, California, April 1982 (2). This highway accident involved a collision between a tanker truck, carrying 8,000 gallons of gasoline, a bus and a stalled car. The ensuing fire burned for 1 3/4 hours, reaching temperatures of 1900°F for at least 20 minutes.

Under the real (vs. IAEA hypothetical) fire conditions, the temperature of the canister would easily exceed 212°F. Since the canisters contain water, the pressure within each canister would likely exceed design conditions releasing steam to the cask cavity. The NRC condition, in the cask Certificate of Compliance, that the cask cavity and inner vessel be dry, makes no sense unless the canisters are dry as well. Since the rupture disks are set at 300 psig, it is possible for the rupture disks to fail, releasing radioactive steam to the environment. Calculations by GE for the IF-300 cask show that pressure would exceed 300 psig due to the contained water.

Recommendation #1: To prevent the possibility of radioactive steam being released to the environment in a long duration fire, the canisters should be shipped completely dry.

Several components of the shipping cask are "thermally-sensitive", including the Neoprene O-rings used to seal the cask (230°F), the BISCO neutron moderators (220°F) and the polyurethane foam overpacks (150°F). In fact, it would be surprising if the foam impact limiters did not shrink solely due to the sun heating the stainless steel skin. While the thermal insulation might not be affected because of the air pockets, the ability to absorb impact, however, would. In their rush to certify the shipping cask, the NRC did not verify whether the impact limiters would be so affected.

The cask contains a thermal shield, a relatively thin stainless steel skin containing water. The thermal shield protects against neutrons, which is not a problem with low burnup TMI fuel. This thin shield would be immediately ruptured in an accident. Contrary to the NRC analysis, the thermal shield should not be counted on to prevent lead melting and thermal degradation of closure seals and BISCO moderators.

The BISCO moderators separate the seven canisters and hold the cask contents subcritical. In a long duration fire, the moderators could melt. If the cask interior was dry, no nuclear reaction would take place. However, if following a fire and destruction of the rupture disks, the cask rolled into water, serious consequences could ensue since the TMI fuel is only 10% used. In this case, the cask would cool, water would enter, and a nuclear reaction would begin. Water would then heat up and be expelled, shutting down the reaction. Water would enter and the reaction would restart. This pulsing phenomenon would continue for several years, each time emitting radioactivity. The consequences of this type of admittedly remote accident are sufficiently grave that the NRC should ensure that the cask and containers are absolutely dry so that the rupture disk does not fail. It may be preferable to install pressure relief valves.

Recommendation #2: In agreement with the REA study, the Model 125-B cask should be redesigned to withstand a two hour fire at 1600°F, and be rebuilt. Components which are thermally sensitive should be replaced.

The NRC should also ensure that local emergency personnel are available to handle a fire, thereby preventing long-duration fires. This can only happen if local personnel are prenotified when the shipments are expected to pass through an area. The DOT should ensure that the cask is kept far from flammable materials, not only while in transit, but in the railyard as well. Though the DOT has few inspectors knowledgable about radioactive materials, it is mandated to ensure safe transit.

Since a film describing the Sandia tests on obsolete containers is shown frequently, it is worthwhile comparing its pertinence to the Model 125-B shipping cask. The Sandia cask had no internal heat source, and was designed to withstand a 1475°F for <u>one hour</u>, rather than 1/2 hour for Model 125-B. The Sandia cask was 90% filled with water. Though the pressure sensors did not operate during the Sandia test, according to a Sandia official, the pressure relief valves opened for about 45 minutes of the 120 minute test, relieving the cask internal pressure, and releasing an unknown amount of water. Sandia failed to measure the amount of water following the fire test. In the case of the Model 125-B cask, the small internal volume of contained water would expand rapidly. Since the Model 125-B cask has no pressure relief valve, the rupture disk would open, and the steam would be released continuously.

<u>Catalytic Recombiner</u>

In one of the great mysteries of the Model 125-B system, almost no information is presented about the catalytic recombiners located within each canister. These devices or materials are designed to recombine hydrogen and oxygen to form water so that H_2 does not build to the point where it explodes. The B & W Canister Appendix has no information on the recombiners. We are therefore mystified how the NRC was able to analyze the safety of the catalytic recombiner, and to specify conditions in the Certificate of Compliance. Under the rush of approving the application, the Certificate Branch neglected to ask for this important information.

• Marvin Resnikoff is a physicist, staff scientist for the Radioactive Waste Campaign, and the author of The Next Nuclear Gamble, Transportation and Storage of Nuclear Waste, published by the Council on Economic Priorities.

REFERENCES:

1. Ridihalgh, Eggers and Associates, Inc., Final Report on Severe Rail and Truck Accidents: Toward a Definition of Bounding Environments for Transportation Packages, prepared for the Nuclear Regulatory Commission, Columbus, Ohio, December 1982.

2. National Transportation Safety Board, Highway Accident Report, "Multiple Vehicle Collisions and Fire, Caldecott Tunnel near Oakland, California, April 7, 1982," NTSB/HAR-83/01, Washington, D.C., May 3, 1983.

APPENDIX B

CHRONOLOGY AND EXPLANATION OF THE CERTIFICATION PROCESS FOR THE MODEL 125-B CASK

The Model 125-B cask was first discussed in a meeting with the Transportation Certification Branch of the U.S. Nuclear Regulatory Commission (NRC) on August 29, 1984, which occurred just after award of the cask supply contract in early August 1984 to Nuclear Packaging, Inc. (NuPac) by EG&G Idaho, Inc. for the DOE. At that meeting and at frequent subsequent meetings with the NRC, the proposed analytical and empirical testing methodology for addressing various technical aspects of the design and analysis of the cask were presented by NuPac and discussed with the NRC. These discussions led to fabrication and drop-testing of a one-quarter scale cask model in early 1985. With the results of the drop-test program incorporated in the Safety Analysis Report (SAR) for the Model 125-B cask (Ref. B-1), submittal of the application to the NRC was made on June 14, 1985, or nine months after the first discussion with the the NRC. After review of the initial SAR submittal, questions from the NRC in August 1985 led to an additional drop-test program using a full-size fuel debris canister in the fall of 1985. A revision to the application which included the canister drop test information was submitted to the NRC on October 31, 1985 and a second set of questions were received from the NRC in December 1985. A second revision of the application, responsive to the NRC questions, was submitted to the NRC on February 11, 1986. After determining that the Model 125-B cask met the requirements of Title 10 of the Code of Federal Regulations, Part 71 (10CFR71) (Ref B-2), the NRC issued the Certificate of Compliance (COC) for the Model 125-B cask on April 11, 1986.

The Model 125-B shipping cask application to the NRC is contained in a three volume SAR available to the public for review. The analyses included in the SAR are extensive and include structural, thermal, containment, shielding and criticality evaluations. From a regulatory viewpoint, the SAR contains the information needed by the NRC to certify the cask as meeting the requirements of 10CFR71. The SAR follows the NRC's recommended approach for application submittals and was prepared in accordance with

NRC Regulatory Guide 7.9, "Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material", (Ref. B-3).

The certification process for the Model 125-B cask may have been completed in less calendar time than previous rail spent fuel shipping cask application reviews, but the total man-months of effort and the facts regarding preparation of the application for the Model 125-B cask show how a timely approval was accomplished while keeping the safety of the public as the primary objective. The review of the application by the NRC was able to proceed with customary care by an early submittal of a complete SAR containing analyses which used only conservative assumptions or documented test results as input values.

NuPac designed the Model 125-B cask for rail transport utilizing the experience gained during design and certification by the NRC of the Model T-3 spent fuel shipping cask which is transported by truck. The design and analysis effort by NuPac of the Model 125-B cask consisted of an almost complete dedication of the company's resources for many months. These considerable man-months of effort were concurrent with detailed technical reviews for the DOE by the Idaho National Engineering Laboratory and Sandia National Laboratories Transportation Technology Center. GPU Nuclear, their contractors and Rockwell Hanford Operations provided additional design and analysis efforts as well as supporting reviews of the various safety analyses. The thorough preparation of the SAR precluded many rounds of written questions and answers during the regulatory review by the NRC. The iterative; i.e., question and answer, method of development of shipping cask safety analysis reports adds time to application reviews when there is not a clear, unambiguous demonstration of compliance with federal regulations as determined by the NRC. The NRC makes the independent evaluation of the SAR and their interpretations of compliance with the regulations are final. Of course, the SAR is also available to the public for scrutiny and the completeness of the SAR is a matter of record.

Besides the extensive efforts by NuPac and DOE contractors to prepare a high quality SAR in support of an uncomplicated and straightforward review, the NRC commissioners and staff have given high priority to TMI-2 cleanup related applications, including fuel shipment. While the TMI-2 cask application had priority from a timely review standpoint, it nevertheless did receive the customary care and thorough independent evaluation with which the NRC Transportation Certification Branch reviews radioactive material packaging applications. The record shows the DOE and its contractors made extraordinary efforts to identify, obtain, and provide to the NRC, the safety related information needed by the NRC on the Model 125-B cask in a timely, responsive manner.

There is no doubt that the drop-testing programs for the one-quarter scale cask model and the full-size fuel debris canister provided supporting test results that substantiated the structural analyses in the cask SAR and were the evidence needed by NRC for a thorough and straightforward application review process. The Model 125-B cask was approved for use in a timely manner not because there was lack of a complete SAR and painstaking review process but because all required analyses were provided and extra efforts were made to prevent application review delays by performing supporting tests. Performance of such drop tests for radioactive material transport packages are not required by the NRC. However, DOE agreed to these extra efforts to conclusively demonstrate the margins of safety in the cask and to fulfill its commitment to contribute to cleanup of TMI-2 in a safe and on-schedule manner.

References

B-1 Safety Analysis Report for the NuPac 125-B Fuel Shipping Cask, NRC Docket No. 71-9200, Rev. 3, July 1986.

B-2 10CFR71, U.S. Nuclear Regulatory Commission, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations, Part 71, Federal Register, 48FR35600, August 5, 1983 and 48FR38449, August 24, 1983

B-3 Regulatory Guide 7.9, Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material, Rev. 1, January 1980

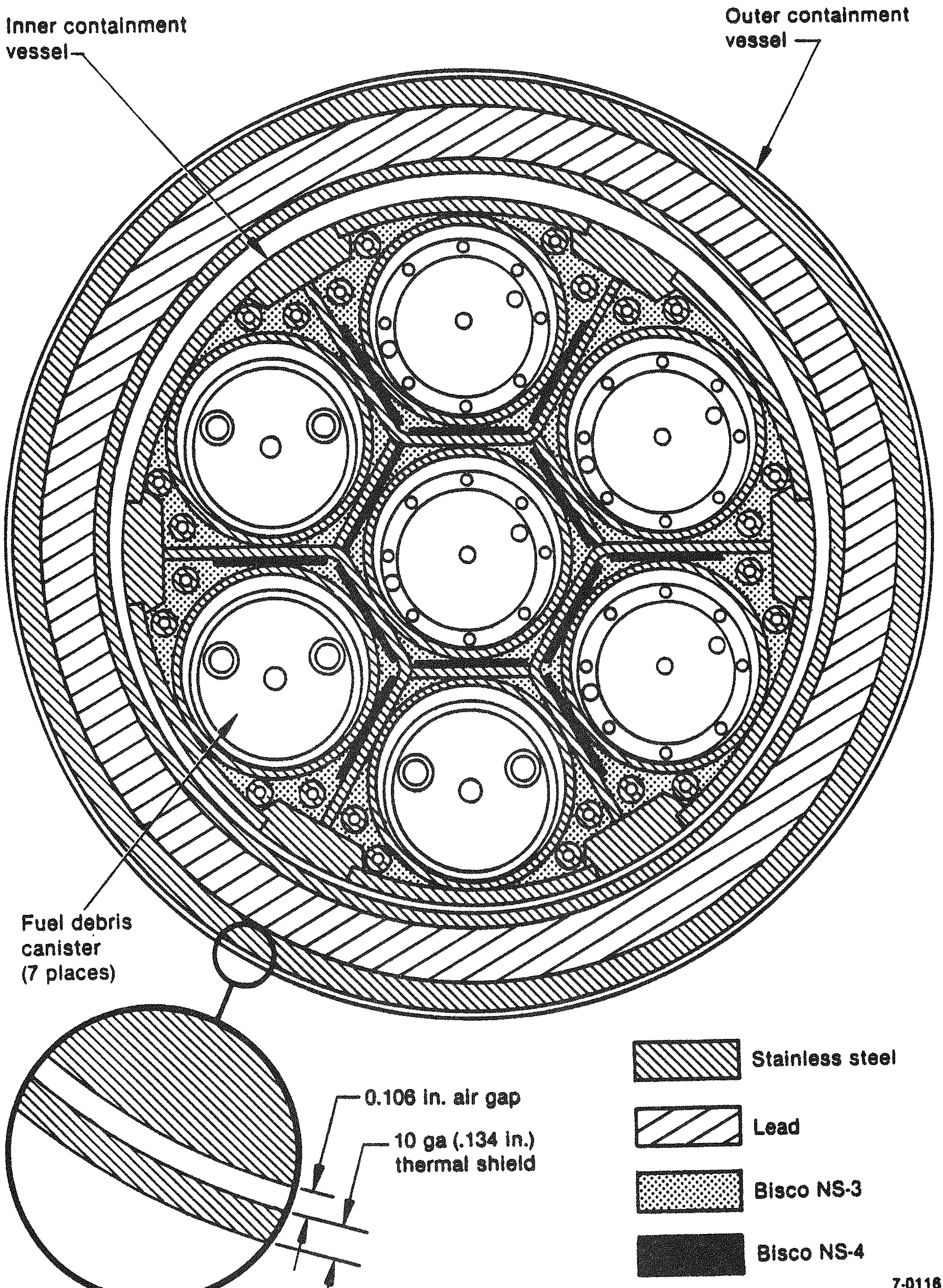
B-4 NUREG 0885, Issue 5, Policy and Planning Guidance, 1986, February 1986

APPENDIX C
DESCRIPTION OF THE THE MODEL 125-B CASK AND PREPARATION OF CANISTERS FOR SHIPMENT

The Model 125-B cask, with fuel debris canisters, consists of three separate barriers (outer containment vessel, inner containment vessel and fuel debris canisters) which provide multiple levels of protection from release of the radioactive materials in the fuel debris to the environment. Failure of all three barriers would be required for such a release to occur. As shown in Figure C1, there is a strong heavily-shielded outer containment vessel with a very thick base and lid. Inside is a separate, removable inner containment vessel with its own thick base and lid. The inner containment vessel holds seven of the containers with fuel debris, called canisters. Each of these three barriers is a substantial structure, designed with sufficiently thick stainless steel to survive large impact loads. The immense amount of metal means a tremendous heat input would be needed to raise the outside temperature enough for the contents of the canisters to experience significant temperature increases.

The first barrier, called the outer containment vessel of the cask, is made of a 2-inch thick external stainless steel shell, a 1-inch thick inner stainless steel shell, and a 4-inch layer of lead sandwiched between the two layers of stainless steel. The lid and bottom plate are each 7.5 inches thick. The outer containment vessel weighs approximately 100,000 lbs, which is a large mass that would require a large amount of heat input to raise the temperature. The outer vessel also has an additional design feature, called a thermal shield, to help reduce heat input into the cask in a fire. The thermal shield consists of ten (10) gauge (0.134 inch thick) stainless steel sheet surrounding the cask outer shell. This shield is spaced out from the cask outer shell by a 12 gauge (0.106 inch diameter) wire wrap on a 3.25 inch pitch spacing.

The inner containment vessel fits inside the outer vessel and provides a second, completely independent containment boundary. The inner vessel has a one-inch thick stainless steel shell and a massive honey-comb shaped structure of stainless steel plates that support seven stainless steel



Inner containment vessel
Outer containment vessel
Fuel debris canister (7 places)
0.106 in. air gap
10 ga (.134 in.) thermal shield
Stainless steel
Lead
Bisco NS-3
Bisco NS-4
7-0116

FIGURE C1

tubes. Filling the space in the structure outside of the tubes are two types of neutron absorbers for criticality control that also provide additional structural strength and rigidity to the inner vessel. With the 5 inch thick lid and two inch thick bottom plate, the inner vessel weighs 37,000 lbs.

Placed in each of the seven tubes in the inner vessel are canisters that are loaded with fuel debris. The canisters are the inner most and the third separate pressure boundary preventing release of radioactive material. Each canister is constructed of 1/4-inch stainless steel and is an American Society of Mechanical Engineers (ASME) code-stamped pressure vessel designed to the ASME Boiler and Pressure Vessel Code to withstand internal pressures of 150 pounds per square inch. Fuel debris canisters weigh over 1000 lbs each and hold many hundreds of pounds of fuel debris.

At TMI, each canister is loaded with fuel debris underwater, since the water is a shielding material that reduces radiation exposures to workers and yet permits visibility while loading the TMI-2 core debris into the canisters. Once each canister is loaded with debris, a lid with an elastomer seal is installed and the eight lid bolts tightened. The canister is then prepared for shipment by a first dewatering using the gas-displacement method. Argon, an inert gas, is fed into a vent connection in the canister lid and water is forced by gas pressure down to the bottom of the canister, up a small-diameter internal drain line and out a drain connection in the lid. With this method, water in the spaces between the pieces of debris is removed and replaced with inert gas. Once inerted, the canister is set aside in a storage rack and monitored to project a gas generation rate. Following the gas monitoring period, each canister is again pressurized with argon gas which removes water that drained by gravity from the surfaces of the debris to the bottom of the canister. After this second dewatering only a small amount of water remains and is present in a canister during shipment.

APPENDIX D

THERMAL ENVIRONMENT SPECIFIED IN THE 10CFR71 REGULATIONS

The International Atomic Energy Agency (IAEA) hypothetical fire accident condition mentioned in the Newsletter is the same as the NRC 10CFR71 regulatory fire accident condition (the regulations applicable to the Model 125-B cask). The complete set of parameters which must be used in evaluating a cask for the hypothetical fire accident condition as stated in 10CFR71, paragraph 73.c(3) is as follows:

> "Thermal. Exposure of the whole specimen for not less than 30 minutes to a heat flux not less than that of a radiation environment of 800°C (1475°F) with an emissivity coefficient of at least 0.9. For purposes of calculation, the surface absorptivity must be either that value which the package may be expected to possess if exposed to a fire or 0.8, whichever is greater. In addition, when significant, convective heat input must be included on the basis of still, ambient air at 800°C (1475°F). Artificial cooling must not be applied after cessation of external heat input and any combustion of materials of construction must be allowed to proceed until it terminates naturally. The effects of solar radiation may be neglected prior to, during, and following the test."

The fire accident condition stated above involves more than just 1475°F for 30 minutes. Other parameters of the fire are specified and were used in computerized thermal analyses for the Model 125-B cask. The thermal effect on the cask considered time, temperature, amount of surface exposed and the radiant heat transfer characteristics of the fire (emissivity) and cask (surface absorptivity). Thus, using just the time and temperature of a fire is not a sufficient description to determine the behavior of a cask in a fire and further questions must be asked when only these are used to describe the severity of a fire. The key variables are not just the temperature and time, but also the amount of heat added through the area exposed to the heat flux.

Since the regulations require exposure of the entire surface of the cask, the cask would have to be suspended in air without support above the surface of the fuel to achieve this requirement. With the Model 125-B cask weighing 90-tons, it would be expected to be on the ground in the event of a train accident and without complete exposure of the entire cask surface to the fire, the total heat flux into the cask would be reduced compared to the calculations in the cask SAR if the other conditions after a train wreck remained the same (fire temperature, duration, emissivity and surface absorptivity). With some of the cask surface on the ground and not exposed to the fire, there would be a heat sink (place for the heat energy to flow to) and a hotter and/or longer duration fire would be needed to input the same heat energy to the cask and contents than has already been assumed by the SAR calculations that are performed in accordance with the 10 CFR71 regulations. The regulations, being a set of engineering conditions with specific values for geometry and heat transfer variables, actually will be more severe than fires which burn at temperatures hotter than 1475°F and longer than 30 minutes when real fire accident conditions are encountered and the cask does not end up in the optimal orientation for heat input.

APPENDIX E

PERFORMANCE OF THE MODEL 125-B CASK

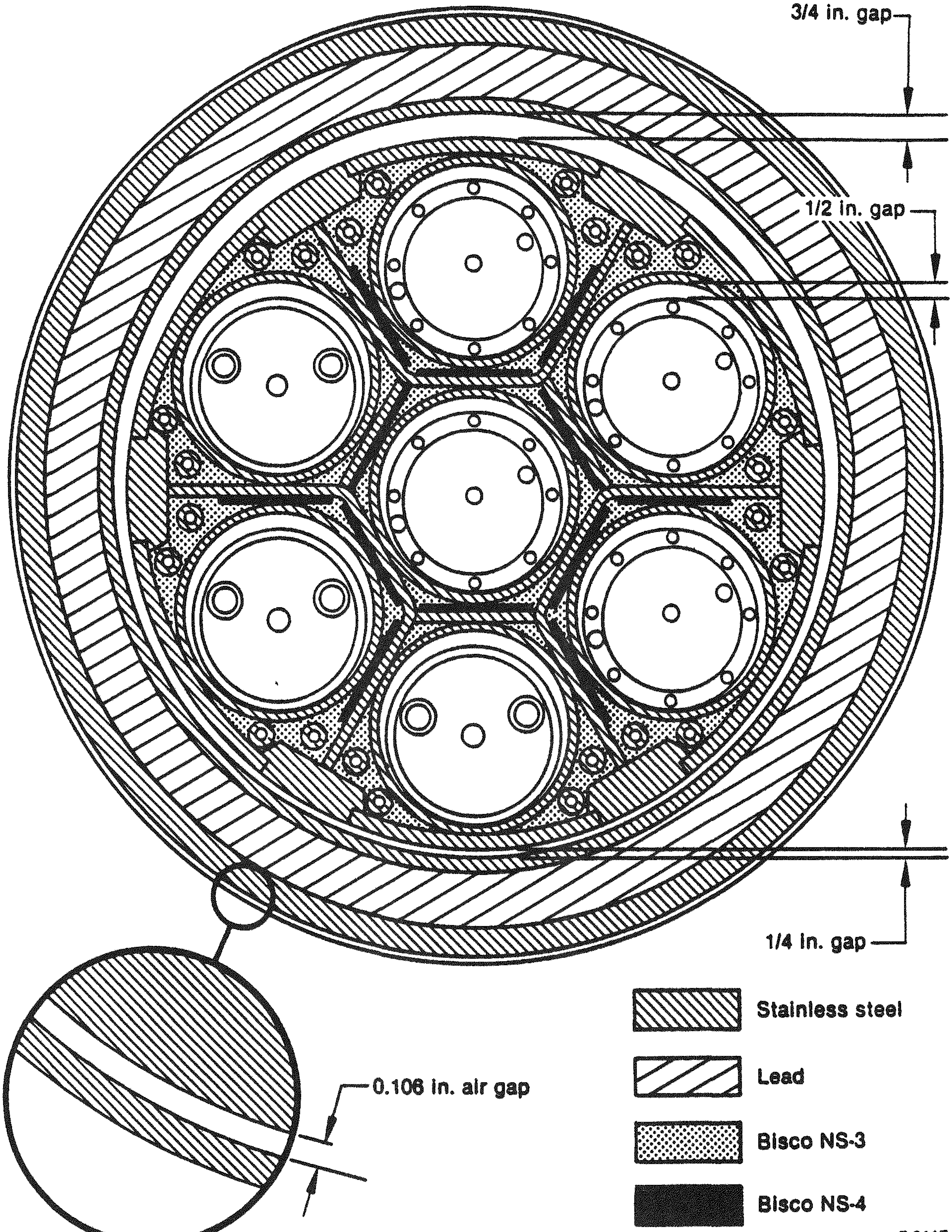
IN THE REGULATORY FIRE AND REMAINING SAFETY MARGINS

As noted in Appendix C on the Model 125-B cask design, there are three separate pressure boundaries providing three levels of protection from release of fuel debris in the event of an accident which includes a severe fire. The accident sequence which must be considered under the 10CFR71 regulations is first a 30 foot drop onto an unyielding surface, then a 40 inch drop onto a puncture bar with a 6-inch diameter, then the thermal environment (fire accident) as described in Appendix D and finally an assumed flooding of the internal cavities with water. With this sequence of events, damage to the overpacks or cask body would occur from the two drop accident conditions before the fire occurs and so damage to these components is included in describing the physical characteristics of the cask in the computerized model used for the thermal analyses.

Two important considerations for understanding the temperature increases as a result of a fire are: 1) the large mass the cask represents which requires a large heat input to raise the temperature and 2) the features of the cask design which retard the heat input and protect the canisters in a fire. These features, as shown in Figure E1, include:

1. Thermal shield: The thin sheet which forms the thermal shield would be exposed to the fire. Heat energy input into the cask's outer shell would have to pass through the air gap formed by the thermal shield. The air gap is a poor heat conductor and heat transfer into the cask during a fire is therefore retarded. Also the polished stainless steel surface of the thermal shield would reflect radiant heat away like a mirror more than absorb heat like a surface painted black.

2. Gap between inner and outer vessel: There is a gap between the inside of the outer vessel and the outside of the inner vessel which is another conductive heat insulator that acts like the thermal shield. The inner vessel's outside surface was designed to remain away from the outer vessel's inner surface and the gap retards the flow of heat into the inner vessel.



3/4 in. gap
1/2 in. gap
1/4 in. gap
0.106 in. air gap
Stainless steel
Lead
Bisco NS-3
Bisco NS-4
7-0117

FIGURE E1

3. There are also gaps between each of the seven canisters and the surfaces of the inner vessel tubes into which they are placed. Only at the bottom of the canister where there is metal to metal contact with the tube would there be a conductive heat path into the canister. The gap around most of the canister surface retards heat flow into the canister and its contents.

Information on temperatures of various components taken from the cask SAR are reproduced below. Four principal heat transfer analyses were performed utilizing the computer thermal network analysis program called MITAS II and are reported in the Model 125-B cask SAR as follows:

(1) Steady state analysis at an outside (ambient) temperature of 100°F with insolation (solar heating). Decay heat from the radionuclides in the fuel debris (about as much heat as from seven 50-watt lightbulbs) and the radiation energy absorbed by the cask from the sun will increase temperatures inside the cask until the outside surface of the cask gets hot enough to dissipate the energy to the 100°F atmosphere.

(2) Steady state analysis at an ambient temperature of 100°F without insolation (solar heating).

(3) Transient analysis of the fire accident condition with puncture bar damage to the thermal shield. That is, the cask has hit a 6" diameter bar and a 9" hole in the thermal shield results. Removing some of the thermal shield provides a path for heat to directly enter the cask's outer shell since the air gap formed by the thermal shield is assumed not to be present.

(4) Transient analysis of the fire accident condition with side drop damage to the overpacks. That is, the cask has fallen on its side from 30 feet onto an unyielding surface and the overpacks have crushed significantly while absorbing the impact energy and protecting the cask. The crushed condition of the overpack is described in the computer model.

The starting conditions for the fire accident are the steady state conditions without insolation. The thermal environment then consists of exposure to an ambient temperature of 1475°F for thirty minutes followed by exposure to 100°F ambient air for a time sufficient for temperatures throughout the cask to maximize. All analyses heat the <u>entire</u> surface of the cask, use emmisivity and surface absorptivity as specified in the 10CFR71 regulations and consider a maximum fuel decay heat load of 100 watts per canister, which is conservative by a factor of approximately two. The following table presents the maximum temperatures determined by these analyses for the major components of the Model 125-B cask.

TABLE E1. MODEL 125-B CASK MAXIMUM TEMPERATURES, °F

	Normal Condition Steady State		Fire Accident Condition Transient	
			Damage	
Location	w/solar heating	w/o solar heating	Puncture Bar	Crushed Overpack
Inner Vessel O-Ring Seal	139	118	123	134
Internal Shield Plug	143	122	128	133
Canister Centerline	180	162	167	166
Canister Shell	161	141	180	180
Inner Vessel Tube	154	133	191	191
BISCO NS-3 and NS-4	148	127	192	192
Inner Vessel Outer Shell	147	127	195	194
Outer Cask O-Ring Seal	135	113	133	228
Outer Cask Inner Shell	135	113	501	495
Lead Shield	135	113	526	517
Outer Cask Outer Shell	135	113	606	600
Cask End Plates	141	120	186	291
Thermal Shield	134	113	1090	1090
Trunnion	129	108	1265	1265
Overpack Shell	135	100	1423	1423

The Newsletter suggests the canister temperature in a fire accident would "easily exceed 212°F" and pressure would then exceed the canister pressure retaining capability due to formation of steam from residual water in canisters. Since vapor or steam pressure is limited by the temperature of the condensing surface available to the vessel cavity, the temperature of the canister centerline (contents) must be raised in excess of the following temperatures to obtain the corresponding steam pressure:

TABLE E2. SATURATED STEAM TEMPERATURES AND PRESSURES

	Saturated Steam
Temperature °F	Pressure lbs/in^2 (absolute)
212	14.696
225	18.915
250	29.82
300	67.01
350	134.62
400	247.25
450	422.61

The canisters are designed for a pressure rating of 150 lbs/in^2 gage (psig) or 165 psi absolute, and are pressure tested to 188 psig. Analyses of the canisters, however, show an internal pressure of 325 psig would be required to reach the design stress values and considerably higher values would be required to yield the structural components. Thus, as the saturated steam table shows, for the canisters to fail from overpressurization due to steam formation, the fire would have to be severe enough to raise the canister condensing surface temperature to over 400°F, or greater than twice the maximum fire transient temperature calculated in the SAR using the regulatory fire conditions. Thus there is a considerable margin of safety in the pressure retaining capability of the canister in the event of a fire more severe than the regulations consider. Likewise, seals on the inner vessel also leave a considerable margin of safety remaining after the regulatory fire condition. As the Table E1 above on cask maximum temperatures shows, the inner vessel seals remain a relatively cool location in the cask during the fire transient, reaching only 134°F. With a recommended operating temperature range of up to 250°F for neoprene, the inner vessel seals would also withstand very severe fires beyond regulatory conditions.

Table E3 summarizes the maximum temperatures predicted for the regulatory fire accident and the recommended temperature range for the material:

TABLE E3. FIRE ACCIDENT

Component	Maximum Temperature (°F)	Max. Recommended Continuous Operating Temp. (°F)
Neoprene Seals		
Inner Vessel	134	250
Outer Vessel	228	250
Ethylene Propylene Seals		
Canisters	180	300
BISCO Neutron Moderators		
NS-3	192	N/A (fire resistant)
NS-4	192	250

As with most materials, the manufacturers recommendations for operating temperatures are on the low side of the point where material property changes begin. Usually, substantially hotter temperatures can be withstood for short-term excursions such as through a fire and subsequent cooldown. Thus the differences in temperature between the maximum predicted by the thermal analyses after the regulatory fire accident and the manufacturer's recommendations are essentially the smallest amount of safety margin which exists. Also, the temperatures which would really be expected if a fire occurred are much lower than those calculated using computerized thermal analyses. The computer modelling in the cask SAR is performed using conservative assumptions as follows:

1) Actual damage to the overpacks, based on drop test results, would be far less than that assumed for thermal analysis purposes and calculated seal temperatures are thus conservatively high.

2) Damage for the puncture bar drop accident was assumed to consist of a 9-inch diameter hole in the thermal shield. This is conservative in that only a 6-inch diameter puncture bar must be considered. This means more area for direct heat input to the cask's outer shell is included in the thermal analyses than would really be the case.

3) Only a 60 degree section of the cask is used to model the cask geometry resulting in the trunnions and puncture bar damage being considered at 6 locations around the cask instead of 2 trunnion and one puncture bar locations. Again more surface area for direct heat input was used than would be expected.

To summarize, the cask SAR thermal analyses, using conservative assumptions, show the cask can safely withstand the regulatory fire. Then, at the maximum predicted temperatures and pressures associated with the regulatory fire, considerable safety margins remain in the cask components such as seals and pressure retaining boundaries. Only at exceptionally high temperatures associated with extremely severe thermal environments would there be a failure of a cask component. The cask would never burst as there are rupture discs provided to ensure a safe depressurization would occur.

APPENDIX F

GAS GENERATION, CATALYTIC RECOMBINERS AND COMPLIANCE WITH COC CONDITIONS FOR GAS CONTROL IN THE MODEL 125-B CASK

U.S. Department of Transportation (DOT) regulations (49CFR173.21) prohibit the transport of radioactive materials containing combustible gases. Some radioactive materials like the TMI-2 core debris could generate combustible mixtures of hydrogen and oxygen gases in a process called radiolysis. These gases are formed when water molecules are split by radiation. Under conditions expected in the canisters, these gases would be generated in a ratio of two hydrogen molecules for each oxygen molecule [two water (H_2O) molecules split into two hydrogen (H_2) plus one oxygen (O_2) gas molecules]. Proven catalyst materials palladium and platinum have been built into the canisters to recombine the gases and reform the water molecules.

At TMI-2 each fuel debris canister is dewatered twice prior to shipment with only a small amount of residual water remaining after the final dewatering. To ensure a safe shipment with this water present, each canister contains beds of catalytic recombiner materials to prevent the buildup of the water decomposition products, hydrogen and oxygen. In order to preclude combustible concentrations of these two gases, a sufficient amount of catalyst was added to each canister so that the recombination capacity will exceed the radiolytic gas generation rate and will ensure very low hydrogen-oxygen concentrations. Rockwell Hanford Operations performed a test program for the TMI-2 canisters to determine the quantities and types of catalyst needed, the shape of the beds, and the safety margin of the recommended catalyst bed design. The safety margin is the amount that the recombination capacity of the catalyst would exceed the maximum probable gas generation rate (the canister which would have the highest calculated gas production rate) while ensuring the oxygen concentration remains below the lower limit of flammability.

Based on the results of the test program, the catalytic recombiner beds are built into each canister as shown in the canister drawings in the B&W canister Appendix in the SAR. Both the canister's upper and lower heads each have beds full of catalyst. The beds in each head contain 100 grams or more of two types of catalyst with at least 20 grams of Atomic Energy of Canada Limited (AECL) wet proof, silicone-coated catalyst and 80 grams or more of Englehard Dexo-D catalyst that fills up the space available for catalyst material. The beds are circular and flat, in a pancake shape that allows a large area for gases to reach the catalyst surfaces and recombine.

The safety margin for the catalytic recombiners built into each canister was found to be a factor of at least 11 for the canister calculated to have the highest gas production rate. In the test program, hydrogen and oxygen gases were fed into a sealed vessel containing a catalyst bed at rates of 0.20 liters per hour of hydrogen and 0.10 liters per hour of oxygen. Those gas feed rates exceeded what was calculated to be the maximum probable gas generation rates in a canister of 0.076 liters per hour of hydrogen and 0.038 liters per hour of oxygen. For the design condition, the highest equilibrium concentration of oxygen found was 1.2 mole (or volume) percent while up to 5.0% is allowed per the regulations. The design condition factor of safety is calculated as follows:

$$\text{Factor of Safety} = \frac{\text{Gas Feed Rate in Test}}{\text{Maximum Probable Gas Generation Rate}} \times \frac{\text{Allowable Oxygen Concentration}}{\text{Equilibrium Oxygen Concentration in Test}}$$

$$\text{Factor of Safety} = \frac{(0.30 \text{ liters/hr})}{(0.11 \text{ liters/hr})} \times \frac{5.0\%}{1.2\%} = 11.4$$

The catalyst test program to develop the recombiners for the canisters was a substantial effort to ensure the safety of the public during transport of TMI-2 fuel debris. The results of the development program through June 1985 were published in reference F-1. The work to ensure safe radiolytic gas control in radioactive materials has been a major DOE effort at TMI-2. Several other reports on the subject have been published as part of the TMI-2 Program. See references F-2 to F-5.

As mentioned above, the catalytic recombiners actually prevent the buildup of radiolytic gases since the gases formed by water molecules that are split by radiolysis are recombined back to water by the catalyst beds at the same rate at which the gases are produced. The concentrations of hydrogen and oxygen gases when the catalytic recombination rate is in equilibrium with the gas generation rate are much lower than the concentrations of these two gases needed to form a combustible mixture (5.0%). The catalyst is very stable and is in no way consumed in the recombination process. Therefore, canisters could be safely stored or shipped in their sealed condition for a very long period of time. If there is something in the loaded core debris canisters which can oxidize and would therefore compete with the catalytic recombiner in removing oxygen gas, then there would be a slow buildup of hydrogen gas. Oxygen concentrations would continue to remain very low, far below the flammable limit.

To further ensure that there is not an excessive buildup of hydrogen or oxygen, a sample of gas is taken from each canister and analyzed prior to shipment. From the gas concentration data and the known time period between canister closure and gas sampling, gas accumulation rates are established for each canister.

An elaboration and explanation of the Certificate of Compliance (COC) for the TMI-2 cask is provided below. The exact wording used in the COC is as follows:

> "For any canister containing water and/or organic substances which could radiolytically generate combustible gases, a determination must be made by tests and measurements or by analysis of a representative canister that the following criteria are met over a period of time that is twice the expected shipment time.
>
> The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the canister gas void if present at STP (i.e., no more than 0.063 g-moles/ft^3 at 14.7 psia and 70°F); or that oxygen is limited to 5% by volume in those portions of the canister which could have hydrogen greater than 5%.

For any package delivered to a carrier for transport, the canister must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the canister is closed and must be completed within twice the expected shipment time."

The first two paragraphs require that by either measuring the gas generation rate or by analysis, it must be shown that flammable gas mixtures will not accumulate in twice the amount of time the shipment is expected to take. The net hydrogen gas accumulation rates measured for the TMI-2 core debris canisters to date have averaged 0.014% per month. Therefore, it would take 360 months on average to reach the 5% regulatory limit for hydrogen. The oxygen concentration would still be very low. Therefore, the average allowable shipping time would be 180 months even if an oxygen source was assumed. These measured data provide confidence that the careful planning, development and design work which resulted in providing catalyst beds in each canister, has minimized or eliminated flammable gas control concerns relating to the TMI-2 core debris shipments.

The third paragraph requires preparation of canisters for shipping in the same way (dewatering, inerting, etc.) they were prepared for the gas generation rate measurement. It further states that the shipping period begins when the canister is closed, and that the actual shipping period from the time the canister is closed until it is delivered at its destination must not exceed twice that expected shipping period.

References

F-1 James O. Henrie and John N. Appel, Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris, GEND 051, June 1985.

F-2 Steven P. Queen, Preparations to Ship EPICOR Liners, GEND 029, June 1983.

F-3 Geoffrey J. Quinn, James O. Henrie and Jess Greenborg, Submerged Demineralizer System Vessel Shipment Report, GEND 035, June 1984.

F-4 James E. Flaherty, Akira Fujita, C. Paul Deltete and Geoffrey J. Quinn, A Calculational Technique to Predict Combustible Gas Generation in Sealed Radioactive Waste Containers, GEND 041, May 1986.

F-5 James O. Henrie, Dann J. Flesher, Geoffrey J. Quinn and Jess Greenborg, Hydrogen Control in the Handling, Shipping and Storage of Wet Radioactive Waste, GEND 052, February 1986.

Appendix M

Examples of Public Response Letters

Appendix M

Examples of Public Response Letters

- David J. McGoff to Pamela jackson letter, dated June 2, 1986
- Kay Drey to Terry A. Smith letter, dated June 17, 1986
- Terry A. Smith to Mrs. Leo Drey letter, dated July 28, 1986
- Frank McCloskey to John S. Herrington letter, dated June 17, 1986
- S. R. Foley, Jr. to Honorable Frank McCloskey letter, dated July 24, 1986
- John Carlin to Honorable John Herrington letter, dated August 4, 1986
- Joseph F. Salgado to Honorable John Carlin letter, dated August 28, 1986
- Robert L. Tagg to A. A. Anselmo letter, dated July 25, 1986
- A. A. Anselmo to Robert L. Tagg letter, dated August 6, 1986
- John Heinz to Honorable John S. Herrington letter, dated July 30, 1986
- S. R. Foley, Jr. to Honorable John Heinz letter, dated August 27, 1986
- Robert T. Stephan to Honorable John S. Herrington letter, dated August 13, 1986
- Joseph F. Salgado to Honorable Robert T. Stephan letter, dated August 28, 1986
- Les J. Davis to Governor Carlin letter, dated July 38, 1986
- A. David Rossin to Ms. Carma Potter letter, dated September 2, 1986
- Liz Paul to Terry Smith letter, dated July 21, 1986
- Terry A. Smith to Liz Paul letter, dated September 24, 1986
- Terry A. Smith to Ann Marie McDonough letter, dated October 7, 1986
- Janine M. Wilson to Ms. Karen Kelley letter, dated October 2, 1986
- Dan Quayle to Honorable John S. Herrington letter, dated December 3, 1986
- John L. Meinhardt to Honorable Dan Quayle letter, dated January 14, 1987
- Terry A. Smith to Frederick A. Brunner letter, dated January 8, 1987
- R. D. Ross to Terry A. Smith letter, dated January 21, 1987
- Kay Drey to Charles E. MacDonald letter, dated March 19, 1987

- Charles E. MacDonald to Mrs. Drey letter, dated June 22, 1987
- Jack Buechner to Honorable John Herrington letter, dated March 26, 1987
- S. R. Foley, Jr. to Honorable Jack Buechner letter, dated April 29, 1987
- Mary L. Walker to Honorable William L. Clay letter, dated March 11, 1987
- S. R. Foley, Jr. to Honorable Arlen Specter letter, dated April 13, 1987
- Mary L. Walker to Honorable Richard A. Gephardt letter, dated March 11, 1987
- S. R. Foley, Jr. to Honorable John C. Danforth letter, dated April 27, 1987
- Liz Paul to Terry Smith letter, dated June 23, 1987
- Terry A. Smith to Liz Paul letter, dated August 6, 1987
- Gay Carraway to Honorable Elizabeth Dole letter, dated July 2, 1987
- John H. Riley to Gay Carraway letter, date unknown
- Gay Carraway to Lawrence H. Harmon letter, dated December 22, 1987
- Lawrence H. Harmon to Gay Carraway letter, dated January 22, 1988
- John Ashcroft to Honorable John S. Herrington letter, dated December 31, 1987
- John S. Herrington to Governor Ashcroft letter, dated March 11, 1988
- Jim Ferlo to Richard D. Sanborn letter, dated August 4, 1988
- Richard D. Sanborn to Honorable Jim Ferlo letter, dated August 25, 1988
- Robert A. Lommler to A. A. Anselmo letter, dated march 9, 1988
- Kay Drey to Lawrence H. Harmon letter, dated April 13, 1988
- Lawrence H. Harmon to Mrs. Leo Drey letter, dated May 23, 1988

RECEIVED

MAY 27 1986

REACTOR RESEARCH AND
TECHNOLOGY DIVISION

Department of Energy
Washington, DC 20545

JUN 2 1986

Ms. Pamela Jackson
Aspen Village, B-6
Rexburg, Idaho 83440

Dear Ms. Jackson:

Thank you for providing us the opportunity to answer your questions regarding the shipment of fuel and structural core materials from the Three Mile Island (TMI) Unit 2 reactor to the Department of Energy's (DOE) Idaho National Engineering Laboratory (INEL) near Idaho Falls. The DOE considers it very important to inform concerned citizens, such as yourself, in Southeast Idaho of activities at the INEL. We hope we can alleviate any concerns you might have.

First, let us provide your some background information on the INEL and the TMI Unit 2 fuel shipping program. The INEL was established in 1949 as the National Reactor Testing Station. Since that time, the INEL has been a national center for development and testing of nuclear energy concepts, with special emphasis placed on developing nuclear safety technologies. Today the INEL is recognized worldwide as a leading center for nuclear safety research and for nuclear waste management and technology development.

The INEL personnel have been stationed at TMI since the accident in March of 1979. There, the INEL personnel have led the way in accident evaluation and in developing safe and effective methods for treatment of the radioactive waste materials. Because of its vast experience in nuclear waste technology development and nuclear waste management, the INEL was selected as the site to store and study the TMI core materials.

At TMI, the fuel and core materials will be loaded into specially-designed canisters. The canisters in turn will be placed inside Type B shipping casks that have been certified by the Nuclear Regulatory Commission. Shipments will be accomplished by rail using high quality track from Pennsylvania to the INEL. The shipping casks were specially designed for the TMI Unit 2 fuel and core materials. A cask testing program conducted at the Sandia National Laboratory in New Mexico demonstrated that the casks will maintain structural integrity and remain leaktight even in the event of a severe shipping accident. Numerous safety procedures have been established to ensure public health and safety while the casks are being loaded, shipped, unloaded, and stored.

Concerning the safety record for the transportation of radioactive materials, in the United States there are approximately 2 million shipments annually of radioactive materials. Of these, about 64,000 are in Type B packages, which are defined as containers designed to transport higher level radioactive materials, such as the TMI Unit 2 materials, and to survive accident conditions without release of contents. According to the most current U.S. Department of Transportation statistics, between 1971 and March of 1985, there were 51 reported transportation accidents involving Type B packages. None of these accidents resulted in package failures or release of contents.

Upon arrival at the INEL, the shipping casks will be delivered to the Hot Shop facility at the INEL Test Area North (TAN), which is located west of the Mud Lake area. The TAN Hot Shop provides complete containment from the environment. Canisters will be removed from the casks and placed in underwater storage bins inside the Hot Shop facility.

At the INEL, the fuel and core materials will be studied and analyzed as part of the DOE's TMI Unit 2 Accident Evaluation Program. This research is of vital importance to the nuclear industry and will ultimately benefit nuclear safety. The studies will provide a complete understanding of the TMI Unit 2 accident sequence and a better understanding of nuclear fuel behavior during severe reactor accidents. The fuel and core materials will be placed in interim storage at the TAN Hot Shop facility until a national repository or other alternatives, such as reprocessing, become available for ultimate disposal.

In the past 25 years at the INEL, there have been no major accidents involving nuclear waste. A few minor handling mishaps have occurred, but because of the nature of the packaging of these materials, none have resulted in release of radioactive wastes.

Again, thank you for your inquiry. We hope we have answered your concerns to your satisfaction. Public information personnel at the INEL are presently preparing information packages regarding the TMI Unit 2 fuel shipping program. This information will be sent to you in the near future.

Sincerely,

David J. McGoff

David J. McGoff, Director
Office of LWR Safety and Technology
Office of Reactor Deployment
Office of Nuclear Energy

bcc:
W. R. Young, ID

Mrs. Leo Drey
515 West Point Avenue
University City, MO 63130

June 17, 1986

Mr. Terry A. Smith
Public Information Department
EG&G Idaho, Inc.
P.O. Box 88
Middletown, PA 17057

Dear Mr. Smith:

Thank you for your letter of May 1 and its enclosures.

I am writing to request additional documents on the TMI-2 Fuel Shipping Program:

1. May I please have a copy, if they are not too bulky, of the following portions of the application for the Fuel Cask 125-B designed and built by Nuclear Packaging, Inc. (i.e., of the Safety Analysis Report)?:

   a. Section 7.0 (operating procedures)

   b. Sections 8.1 (acceptance tests) and 8.2 (maintenance program); and

   c. Appendix 7.4 (tests)

2. Is there any document published that compares the cask and canister tests required to be performed under 10 CFR 71 and the Certificate of Compliance #9200 -- with those tests actually performed to date, and the results? If so, may I please have a copy?

   I am particularly interested in understanding more about the nature and effects of the recombiner catalysts. (By the way, shouldn't these, rather, be called anti-recombiner catalysts?) Can you summarize for me the experiences that have already been documented on the effectiveness of these catalysts in reducing water formation? Have you found that any of these experiences have related directly to the TMI defueling canisters presently located in storage racks?

3. May I please have a copy of the following:

   a. Oak Ridge National Laboratory letter report by L. B. Shappert: "Tests of the TMI Knockout Canisters," October 11, 1985; and

   b. Babcock & Wilcox Final Report: "Drop Testing of Defueling Canisters," Document # 77-1156373-00; February 1985.

I would be happy to pay for photocopying and postage. Thank you.

Sincerely,

Kay Drey

EG&G Idaho Inc
PO Box 88, Middletown, PA 17057

July 28, 1986

Mrs. Leo Drey
515 West Point Avenue
University City, Missouri 63130

REQUEST FOR ADDITIONAL TMI-2 FUEL SHIPPING INFORMATION - TAS-11-86

Ref: a) K. Drey ltr to T. A. Smith, Request for Additional Documents, June 17, 1986
b) K. Drey ltr to T. A. Smith, Request for Additional Documents, July 21, 1986

Dear Mrs. Drey:

Per your recent requests in the reference letters, responses to your questions are listed below:

Response 1. Sections 7.0 (including 7.4), 8.1 and 8.2 of the Model 125-B Cask Safety Analysis Report (SAR) are enclosed.

Response 2. Please be advised that the hypothetical accident condition tests are not required to be performed under 10CFR 71. The requirement in 10CFR 71.73(a) states: "Test procedures; Evaluation for hypothetical accident conditions is to be based on sequential application of the tests specified in this section, in the order indicated, to determined their cumulative effect on a package or array of packages." The determination may be made either by analysis or by testing. For the 125-B cask both analyses and testing were used. The analytical results were complimented by many tests which substantiate values for parameters used in the analyses (for example, impact forces used in structural analyses). A scale model of the cask was made and drop tested for the free drop (30 feet onto an unyielding surface) and puncture (40 inches onto a puncture bar) hypothetical accident conditions. Also, a full size knockout canister was drop tested for the free drop accident condition. The results of these drop tests are not "published" yet but are in the 125-B cask SAR and are available to the public from the NRC's Public Document Room. The SAR also contains the results of tests on cask and canister components (overpack foam thermal performance, neutron moderator off-gassing, fuel canister impacts, etc.).

Results of tests required by the Certificate of Compliance and SAR are not submitted to NRC and not available from the NRC's Public Document Room.

Regarding recombiner catalysts, please be advised that these materials function to recombine hydrogen and oxygen gases into water. These two gases are generated by radiolysis of water in wet radioactive materials. To prevent formation of combustible mixtures of these two gases, catalysts control their concentration by recombining them back into water. The test program results are documented in a report titled, "Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris", (GEND 051, June 1985). A copy of this report is enclosed.

To date, after storage of TMI defueling canisters for gas generation monitoring, the experience has been consistent with the tests. The samples of gases obtained after storage have had hydrogen concentrations below the lower limit of detectability of the gas chromatograph.

Response 3. Per your request, enclosed please find:

a. Oak Ridge National Laboratory letter report by L. B. Shappert: "Tests of the TMI Knockout Canister," October 11, 1985; and

b. Babcock & Wilcox Final Report: "Drop Testing of Defueling Canisters," Document #77-1156373-00; February 1985.

Per Reference b), enclosed is "Radiological Impacts of Transporting Three Mile Island Core Debris," EGG-TMI-7108, January 1986.

Thank you for your interest in the TMI-2 fuel shipping program.

Very truly yours,

Terry A. Smith
Public Information Officer

cmr

Enclosures:
As Stated

6TH DISTRICT INDIANA

ARMED SERVICES COMMITTEE

SUBCOMMITTEES
RESEARCH AND DEVELOPMENT
INVESTIGATIONS

POST OFFICE AND CIVIL SERVICE COMMITTEE

SUBCOMMITTEE
CHAIRMAN POSTAL PERSONNEL AND MODERNIZATION

Congress of the United States
House of Representatives
Washington, DC 20515-1408

202-225-4636

DISTRICT OFFICES
WINFIELD K. DENTON FEDERAL BUILDING
ROOM 124
101 NW SEVENTH STREET
EVANSVILLE IN 47708-1951
812-465-6484

217 NORTH SALE STREET
ELLETTSVILLE IN 47429-1423
812-876-7750

28 NORTH FIFTH STREET
VINCENNES IN 47591-2016
812-886-9328

June 17, 1986

The Honorable John S. Herrington
Secretary, Department of Energy
1000 Independence Ave. SW
Washington, D.C. 20585

Dear Secretary Herrington:

It has come to my attention, albeit indirectly, that the Department of Energy intends to transport nuclear core materials from Three Mile Island to the Idaho National Engineering Laboratory in Idaho Falls. It is my understanding that one of the proposed routes for the rail shipment is on the B & O lines through my District in Southern Indiana, including the two towns of Washington and Vincennes.

Needless to say I am very distressed that I was not made aware of this proposal by your office, or any other government agency, but through second hand information. It would seem that in a decision of this magnitude, the Department would actively solicit the views of the Representatives of the areas affected. This failure to consult and notify leads me to the conclusion that a full and complete review of the matter has not been undertaken, and that the determination of the route may have been made without sufficient information.

I am greatly concerned that the decision may have been made on a the basis of least cost, rather than concern for safety or after a full investigation of alternate routes or modes of transportation. I therefore request answers to the following questions:

1. Has there been a decision to transport nuclear core materials by rail from Three Mile Island through the State of Indiana?

2. If so, what route has been chosen?

3. What was the decision making process used to determine the mode and route of transportation?

4. What alternatives were available, and why were they not chosen?

5. Has the Department of Energy transported nuclear materials over these tracks previously?

6. Have these tracks been inspected recently, and if so, when and by whom?

7. Why is it necessary to remove these materials from Three Mile Island, rather than store them at the site?

8. What is the policy of the Department of Energy concerning notification to local, state and federal officials of plans to transport nuclear materials through their areas?

I would appreciate your earliest attention to this inquiry.

Sincerely,

Frank McCloskey

Frank McCloskey
Member of congress

FM/grl

JUL 24 1986

Honorable Frank McCloskey
House of Representatives
Washington, DC 20515-1408

Dear Mr. McCloskey:

Thank you for your letter of June 17, 1986, to Secretary of Energy John S. Herrington regarding the shipment of Three-Mile Island (TMI) nuclear core materials. As the Department of Energy (DOE) organization responsible for transportation of radioactive materials, your letter has been sent to me for a reply.

The DOE is shipping the TMI-2 core to its Idaho facility for storage and examination as part of its research and development program. This program has produced significant information on recovery from a serious reactor accident. Examination of core materials at DOE's Idaho facility is expected to provide additional data that will greatly benefit future design and regulation of nuclear reactors. The decision to remove the core materials from TMI is in accordance with the memorandum of understanding between the DOE and the Nuclear Regulatory Commission (NRC).

The decision to move the TMI core material was made very carefully. Our main concern is always the health and safety of all citizens and protection of the environment. Please be assured that we exercise the utmost care in these activities.

A decision to move the TMI core material, using specially designed NRC-certified casks, has been made. We plan to make these shipments by rail using mainline routes on Conrail and the Union Pacific railroads. The route from Pennsylvania to Idaho will include the State of Indiana. It begins east of Muncie and passes through Indianapolis. Shipments leave the State near Terre Haute. The route does not include Washington or Vincennes.

The decision on the mode of transportation (rail vs. truck) was made to reduce the number of shipments. We plan 35-40 rail shipments where about 250 truck shipments would have been needed. Route selection was based on using the best track and shortest shipping time reasonably available. We do avoid population centers where possible. The Department of Transportation guideline is to minimize time in transit and rail shipment over excellent track does just that. We believe we have selected the best alternative.

It would take an exhaustive records search to determine if DOE has transported nuclear materials over these tracks previously. However, rail

Revised per CP-35:Vandertill:7-23-86:previous concurrences valid shipments are routinely made throughout the United States and have been for over 40 years. We have no information on recent track inspection, but the Federal Railroad Administration will inspect the entire route before shipments begin.

You ask about the need to remove the core material. Cleanup of TMI is a difficult task and much is being learned about recovery from such an incident. We expect to learn more as we closely examine the core material.

Finally, you ask about DOE policy on notification to local, State, and Federal officials of plans to transport nuclear materials through their areas. The DOE transportation procedures for unclassified spent fuel shipments provide for generic notification and courtesy communication to the Governors' designees for each State along the route. The representatives in each State have the responsibility for informing other State and local officials. These notifications were made for the TMI shipments in February 1986. In the State of Indiana, both the Governor's designee, John T. Shettie, and the Superintendent of the Indiana State Police were contacted.

Again, we are pleased to respond to your questions. If I can be of any additional assistance, please feel free to contact me.

Sincerely,
(signed)
D. Ofte
for S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

DP-121
RGarrison
7- -86
DP-121
LHarmon
7- -86
DP-12
THindman
7- -86
DP-12
JLytle
7- -86
DP-10
JMeinhard
7- -86
DP-3
JGilbert
7- -86
DP-2
DOfte
7- -86

Distribution:
so: Addressee
1bcc: ES (ES86-009611/Due: 6-30-86) w/orig. incmg & ticket
1bcc: CP-30 w/copy ticket & incmg
4bcc: DP/MR
2bcc: DP-12
1bcc: Originator
1bcc: DP-10 Suspense
1bcc: NE-1
1bcc: MA-1
1bcc: CP-1
1bcc: DP-1
1bcc: DP-121 Rdr
1bcc: DP-12 Suspense
1bcc: EH-1
1bcc: CP-1
1bcc: MA-2
DP-121:LHarmon:ebm:353-3506:7-1-86:WANG 1776o (file: 5822.6)
Revised per NE-1:sjs:7/15
Revised per DP-2 (Ofte):sjs:7/18/86

Correspondence Reviewer: G. Payne
DP Control Number: DP-86-007279

EH-1	NE-1	CP-1	CP-35	CP-40
7- -86	7- -86	7- -86	7- -86	7- -86

STATE OF KANSAS

OFFICE OF THE GOVERNOR
State Capitol
Topeka 66612-1590

John Carlin *Governor*

August 4, 1986

The Honorable John Herrington
Secretary of United States
Department of Energy
1000 Independence Ave. S.W.
Washington, D.C. 20585

Dear Secretary Herrington:

In reference to the recent shipment of Three Mile Island wastes through Kansas, I am pleased with the cooperation we have received from the U.S. Department of Energy regarding pre-shipment notification and providing other pertinent information. However, several questions have been raised as to whether the first shipment was made in complete compliance with the Certificate of Compliance issued to DOE by the Nuclear Regulatory Commission for those shipments and with the requirements of the National Environmental Policy Act of 1969. More specifically, I am concerned whether the regulation requiring an environmental impact study was complied with, as well as possible violations of the time requirements for shipment of the materials following the sealing of the canisters.

In seeking answers to these questions on my behalf, Mr. Leon Mannell of the Kansas Adjutant General's Department, Division of Emergency Preparedness, has talked with Mr. Terry Smith of DOE's Idaho Operations Office. Mr. Smith has addressed the questions raised and assured Mr. Mannell that, in so far as he is aware, the first shipment was made in complete compliance with all applicable federal statutes, laws and requirements.

The federal statutes, regulations and requirements are designed to protect the health and safety of the citizens along the route. Under current statutes and regulations, we must rely totally on the Department of Energy to insure that shipments of this nature are made as safely as possible. It is imperative that you do everything possible to see that the TMI Shipping Program is conducted in complete compliance with all applicable federal requirements. Because of the serious nature of these shipments, I am requesting that you conduct a full review of the procedures followed in the recent shipment of Three Mile Island wastes to determine if there was strict compliance with the appropriate regulations, and request notification of the findings of this review.

Your prompt attention to this matter is appreciated, and I look forward to DOE's continued cooperation in addressing questions and concerns which arise regarding the program.

Sincerely,

JOHN CARLIN
Governor

cc: Major General Ralph T. Tice
Barbara J. Sabol, Secretary of Health & Environment
The Honorable Robert T. Stephan
The Honorable Bob Dole
The Honorable Nancy Landon Kassebaum
The Honorable Jim Slattery
The Honorable Jan Meyers
The Honorable Dan Glickman
The Honorable Bob Whittaker
The Honorable Pat Roberts

Department of Energy
Washington, DC 20585

August 28, 1986

Honorable John Carlin
Governor of Kansas
Topeka, Kansas 66612

Dear Governor Carlin:

Thank you for your letter to Secretary Herrington of August 4, 1986, regarding shipments of spent nuclear fuel from Three-Mile Island (TMI) in Pennsylvania to Idaho Falls, Idaho. The specific concerns raised in your letter have indeed been considered, and a review of the procedures followed was performed.

Our review shows the first shipment from TMI-2 was performed in a manner which met or exceeded all the applicable Federal statutes, regulations, or requirements. Specifically, these shipments are being made in full compliance with the Nuclear Regulatory Commission cask Certificate of Compliance requirements and requirements of the National Environmental Policy Act (NEPA). Enclosed you will find a detailed discussion of the questions you raised on shipping time and NEPA.

The protection of the health and safety of citizens along the route has always been and continues to be a primary concern of the fuel shipping program. Key to meeting this objective was designing an accident-resistant shipping cask to retain the TMI-2 core debris even in very severe accidents. We have also enclosed a brief description of the important safety-related elements of the TMI-2 casks and shipping procedures.

The TMI-2 fuel shipping program is a safe, secure, and well-monitored effort and complies with applicable regulations. We believe your review of the Department's efforts will lead to the same conclusion.

If I can be of further assistance, please do not hesitate to contact me.

Yours truly,

Joseph F. Salgado
Under Secretary

Enclosures: As stated

cc: Honorable Robert T. Stephan
Attorney General, State of Kansas

STATE OF NEBRASKA

ROBERT KERREY • GOVERNOR • COL. ROBERT L. TAGG • SUPERINTENDENT

July 25, 1986

A. A. Anselmo
E.G.G., Inc.
P.O. Box 1265
Idaho Falls, ID 83415

Dear Mr. Anselmo:

This letter will confirm our telephone conversation on this date regarding shipments of 3-Mile Island nuclear waste across Nebraska.

As you are aware, the Nebraska State Patrol has been designated by Governor Kerrey as the single point of contact in the state of Nebraska in matters such as these.

We would appreciate notification of the approximate date and time shipments can be expected to arrive and depart Nebraska, route of the shipment through Nebraska, and any other information that you feel would be helpful to the Patrol in the event of any accident that might befall the shipment.

Inasmuch as we will assign troopers who have been trained in the handling of hazardous materials to escort the train, as much advance notice as you can give us would be appreciated.

We realize that this matter should be kept confidential and on a need-to-know basis.

Very truly yours,

R. L. Tagg

Robert L. Tagg, Colonel
Superintendent

ms

48a119

NEBRASKA STATE PATROL, BOX 94907, LINCOLN, NEBRASKA 68509-4907, PHONE (402) 471-4545

INEL
Idaho National Engineering Laboratory

W. N. Bixby
P. J. Grant
T. A. Smith
Central File - 83581
TMI File
A. A. Anselmo File

August 6, 1986

Col. Robert L. Tagg
Nebraska State Patrol
Box 90907
Lincoln, NE 68509-4907

CONFIRMATION OF INFORMATION REGARDING TMI SHIPMENTS - AAA-328-86

Dear Col. Tagg:

This is to advise you that I have received your letter of July 25, 1986, and have taken the necessary steps to implement procedures whereby you will be notified the approximate date and time all TMI shipments will arrive and depart the State of Nebraska as well as the specific route through Nebraska.

Verbally, you gave me the following contacts and telephone numbers:

Col. Robert Tagg: (402)471-4545 (24 hr. no.)
Major Ron Witkowski: (402)471-4545 (24 hr. no.)
Lt. John Buist:
Capt. E. E. Folkers:

If any of the above is incorrect, please advise us as soon as possible so we can make the necessary changes.

In accordance with our conversation of July 25, 1986, you advised me that a letter of agreement between your state and DOE existed regarding these notifications. I have still been unable to locate a copy of that letter and would appreciate your sending me a copy at your earliest convenience.

If additional information is requested, please contact my office on (208) 526-2414.

Very truly yours,

A. A. Anselmo
Traffic Manager

kk

EG&G Idaho Inc P.O. Box 1625 Idaho Falls, ID 83415

United States Senate

COMMITTEE ON FINANCE
WASHINGTON, DC 20510

July 30, 1986

The Honorable John S. Herrington
Secretary
Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585

Dear John:

I would like to express my strong concerns regarding the Department of Energy's shipments of radioactive debris from the Three Mile Island nuclear reactor in Harrisburg, Pennsylvania to an Idaho repository.

My concerns are twofold. First, I am dismayed that the Department has chosen to route the shipments on a rail line that goes through several densely populated areas of Pennsylvania, including the cities of Pittsburgh, Johnstown, Harrisburg, and Altoona. In the interest of public safety, I would urge you to consider alternative routes to transport these materials that do not pass through major cities in Pennsylvania and other states en route to Idaho.

In addition, it is my understanding that many local officials in Pennsylvania were not given advance notice that the first Three Mile Island shipments would be passing through their jurisdictions last week. With respect to future shipments, I request that DoE keep all affected local officials fully advised so that they may make appropriate preparations.

It is my hope that the DoE will reconsider its route selection and public notification processes so that the remaining shipments of Three Mile Island materials may be transported in a manner that minimizes risks to public safety.

Thank you for your attention to this matter.

Sincerely,

John Heinz
United States Senator

JH/erk

00-070410

AUG 27 1986

Honorable John Heinz
United States Senator
Washington, DC 20510

Dear Senator Heinz:

Thank you for your letter of July 30, 1986, to Secretary of Energy John S. Herrington regarding the transportation of spent fuel rods from Three-Mile Island (TMI). As the Department of Energy (DOE) organization responsible for transportation of radioactive materials, your letter has been sent to me for a reply.

We appreciate your interest in this matter and understand the concerns of the cities along our route. We share a mutual concern for the health and safety of all citizens and protection of the environment. Please be assured we use the utmost care in our transportation activities.

Route selection was based on Department of Transportation guidelines. These recommend using the best route available and minimizing the time in transit. DOE, jointly with the rail carriers, selected a route that uses the highest quality track available and minimizes time in transit. Direct routes avoid diversions and excessive switching delays. While population density is a factor we consider in route selection, it is sometimes necessary to ship through large metropolitan areas because the highest quality track passes through these areas. As an added safety measure, we asked the Federal Railroad Administration to inspect the entire route to assure its safety.

Although routing is a factor in the safe transportation of spent fuel, the most important safety consideration is the package. The Department is using special spent fuel casks certified by the Nuclear Regulatory Commission specifically designed to ensure the contents are safely contained even in a severe accident. I have enclosed a fact sheet that addresses in greater detail concerns about the TMI shipments.

You requested DOE to keep all affected local officials fully advised so that they may make appropriate preparations. We have discussed this matter with the Pennsylvania Emergency Management Agency (PEMA), which receives information directly from the DOE. PEMA has the authority to provide this information to assist local emergency response planning when needed. Local officials should contact Mr. John Patton, Director of PEMA.

I appreciate the opportunity to respond to your letter.

Sincerely,

(signed)
D. OFTE

For S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

Enclosure

Distribution:
so: Addressee
4bcc: ES (ES86-011673/Due:8-~~8~~ 26-86) w/orig. incmg & ticket
1bcc: CP-30 w/copy ticket & incmg
1bcc: CP-1
4bcc: DP/MR
1bcc: DP-1
2bcc: DP-12
1bcc: DP-121 Rdr
1bcc: Originator
1bcc: DP-12 Suspense
1bcc: DP-10 Suspense
1bcc: EH-1
1bcc: NE-1
1bcc: PE
1bcc: GC-31
1bcc: MA-1
1bcc: MA-2
1bcc: RW-33
DP-121:PGrimm:ebm:353-3506:8-11-86:WANG 1898o (file: 5822.6)

Correspondence Reviewer: G. Payne
DP Control Number: DP-86-007544

EH-1	NE-1	CP-35	CP-1
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CONCURRENCES

RTG SYMBOL	INITIALS/SIG	DATE
DP-121	PGrimm	8-15-86
DP-121	LHarmon	8-19-86
DP-12	THFridman	8-19-86
DP-12	JLytle	8-19-86
DP-10	JMeinhard	8- -86
DP-3	JGilbert	8- -86
DP-2	DOfte	8- -86
CP-35		8- -86
CP-30		8- -86

Summary of Three-Mile Island (TMI) Transportation, Environmental, and Programmatic Requirements

Environmental Review:

The National Environmental Policy Act of 1970 requires Federal agencies to consider the environmental effects of proposed major Federal actions. The environmental effects of this program were considered and the Department concluded, as is the case for other current spent fuel shipments, there would be no significant environmental impact. The impacts of the TMI shipment program are bounded by those described in the Nuclear Regulatory Commission's (NRC) report NUREG-0170, Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes. The Commission concluded the environmental impacts of normal transportation of radioactive material and the risks of accidents involving radioactive materials shipments are sufficiently small to allow shipping by all modes. Further, the Commission stated transportation under present regulations provides adequate safety to the public. The probable risks evaluated in that study remain the same today and continue to provide justification for package testing standards issued by the NRC.

This environmental impact statement was also used by the Department of Transportation (DOT) and upheld by the courts to support a uniform national routing regulation for transporting radioactive materials, Highway Routing of Radioactive Materials, Docket No. HM-164. The DOT concurred with the NRC that the transportation of radioactive materials is a low-risk activity by any level of comparison.

A specific environmental impact statement was also issued by the NRC related to the programmatic effects of handling the TMI spent fuel, Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979, Accident--Three-Mile Island Nuclear Station, Unit 2, NUREG-0683. This study included review of the transportation aspects supporting removal of the fuel. We have enclosed an abstract from this environmental impact statement for your review.

TMI Fuel Analysis:

The TMI spent fuel being transported is damaged core material from the TMI-2 reactor. The Department of Energy (DOE) is shipping this material to its Idaho facility for storage and examination as part of its research and development program. This program has produced significant information on recovery from a serious reactor accident. Examination of core materials at DOE's Idaho facility is expected to provide additional data that will greatly benefit future design and regulation of nuclear reactors.

Cleanup of TMI is a complex task and much is being learned about recovery from such an incident. We expect to learn even more as we closely examine the core material. More importantly, we want to make sure TMI does not become a long-term waste disposal site.

Transportation Aspects:

The decision to transport the TMI core material was made very carefully. Our main concern is always the health and safety of all citizens and protection of the environment. Rail was chosen as the mode of transportation in order to reduce the number of shipments. We plan 35-40 rail shipments. Two-hundred fifty truck shipments would have been needed.

In compliance with the DOT guidelines for routing large quantities of radioactive materials so that time in transit is minimized, these rail shipments are conducted over shortest distances on higher quality mainline tracks. We avoid population centers where possible.

As a further safety precaution, the Federal Railroad Administration (FRA) has inspected the entire route the shipments use. In addition, the rail carriers routinely inspect the tracks to ensure their quality. TMI shipments are routinely inspected before shipment by the DOE, NRC, DOT, and FRA officials. Similar radiological and vehicular inspections are conducted at the destination facility in Idaho. Finally, specific States are monitoring shipments en route in support of local emergency response efforts.

Each segment of transportation for the TMI shipments will comply with applicable regulations of the DOT under the authority of the Hazardous Materials Transportation Act. DOT has established extensive safety regulations for radioactive materials transport including, but not limited to, requirements for inspections, packaging, monitoring, training, security, and reporting.

In the more than 40 years of transporting radioactive materials across the United States, we have achieved an exemplary record of safety. Although there is public apprehension about shipping spent fuel, there has never been an injury or death attributable to radiation as a result of an accident involving its transportation.

Transportation Cask Safety:

The NRC has licensed the two casks being used for TMI shipments. Also, new heavy-duty railcars are being used which have been approved by the Association of American Railroads.

Unlike other hazardous materials, the radioactive materials shipping container provides the primary safety factor in transporting materials, assuring protection to the public, transport workers, and the environment. The casks used by the DOE for spent fuel shipments are designed to ensure the contents are safely contained even in the event of a severe accident. Rigorous design, analysis, and testing programs have repetitively demonstrated cask survival even when subjected to fire, collision, puncture, or water immersion scenarios beyond what is experienced in "normal" transport accidents.

Liability for an Accident:

In the event of a nuclear transportation incident (irrespective of how remote such a possibility may be) there is a broad umbrella of financial protection for public liability through the Price-Anderson Act (42 USC sections 2014, 2210). Protection would be provided for liability resulting from a nuclear incident arising out of the transportation of spent nuclear fuel. This protection is afforded not only to the carrier, but also any other person or entity who might be liable to the public for damages resulting from a nuclear incident.

STATE OF KANSAS

OFFICE OF THE ATTORNEY GENERAL

2ND FLOOR, KANSAS JUDICIAL CENTER, TOPEKA 66612

ROBERT T. STEPHAN
ATTORNEY GENERAL

MAIN PHONE (913) 296-2215
CONSUMER PROTECTION 296-3751
ANTITRUST 296-5299

August 13, 1986

The Honorable John S. Herrington
Secretary, U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Re: Shipment of Radioactive Materials for Three Mile Island Unit 2

Dear Secretary Herrington:

It has come to the attention of this office that your agency is intending to transport additional shipments of high-level radioactive waste from the damaged Three Mile Island Unit 2 reactor site to the Idaho National Engineering Laboratory in Idaho. The first such shipment, as you know, passed through the State of Kansas. I am attempting to determine whether all possible precautions and planning have been accomplished to ensure that subsequent shipments are accomplished consistent with applicable law and the public's best interests.

Specifically, has your agency or any other federal agency prepared a route-specific environmental impact statement as required by the National Environmental Policy Act (NEPA) 42 USC §4321 <u>et seq</u>.? If such has not been conducted, has your agency or any other federal agency conducted a route-specific environmental assessment as required and described at 40 CFR §§1501.4(b), 1508.9? In our judgment, a route-specific analysis is required in order to comply with NEPA.

We are aware that an Environmental Impact Statement has been issued by the U.S. Nuclear Regulatory Commission for the decontamination and disposal of radioactive wastes from T.M.I. However, our review of Chapter Nine of the E.I.S. which discusses, <u>inter alia</u>, transportation of fuel and solid waste, indicates that the analysis focused on truck transportation rather than rail transportation. In our judgment, a comprehensive analysis of the environmental impact of rail shipments should be done in order to comply with the requirements of NEPA.

Additionally, it is our understanding that the Certificate of Compliance issued to your agency by the N.R.C. (certificate number 9200; docket number 71-9200) requires that the "shipment period begins when the canister is closed and must be completed within twice the expected shipment time." (Certificate of Compliance, p. 4.) Has this particular provision been amended to provide a different shipment period? Was the shipment period provision (whether amended or not) complied with in the first shipment from T.M.I. to Idaho?

Finally, we have reviewed an analysis by Marvin Resnikoff of the Model 125-B T.M.I. shipping cask that is apparently being utilized in the shipments. This analysis (copy enclosed) raises issues which focus on the ability of the cask to handle extreme thermal burdens. We would greatly appreciate any response to this analysis which you may provide which indicates that the conclusions reached by Mr. Resnikoff are in error.

Please understand, we make these inquiries in the interest of protecting the health and safety of the citizens of Kansas. Because these matters are of great importance, we request that your response be provided to this office prior to the next shipment of radioactive material from T.M.I.

Thank you for your cooperation and we look forward to hearing from you in the near future.

Very truly yours,

Robert T. Stephan

ROBERT T. STEPHAN
Attorney General

RTS:crw
Enclosure

cc: Major General Ralph T. Tice
Barbara J. Saboi, Secretary of Health & Environment
The Honorable John Carlin
The Honorable Bob Dole
The Honorable Nancy Landon Kassebaum
The Honorable Jim Slattery
The Honorable Jan Meyers
The Honorable Dan Glickman
The Honorable Bob Whittaker
The Honorable Pat Roberts

Department of Energy

Washington, DC 20585

August 28, 1986

Honorable Robert T. Stephan
Attorney General
State of Kansas
Topeka, Kansas 66612

Dear Mr. Attorney General:

This is in reference to your letter of August 13, 1986, regarding shipments of spent nuclear fuel from the Three Mile Island Unit 2 reactor to the Idaho National Engineering Laboratory in Idaho. Our review of the first shipment and the procedures planned for subsequent shipments indicates that these shipments are being made in full compliance with the National Environmental Policy Act (NEPA) and the requirements of the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT).

The environmental impacts of the transportation of radioactive materials by various transportation modes are exhaustively examined in the Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes, NUREG-0170. In addition, the potential impacts and risks from the shipment of TMI irradiated fuel are specifically addressed in detail in yet another EIS, the Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979, Accident - Three Mile Island Nuclear Station, Unit 2, NUREG-0683.

Additional route specific NEPA review is not required. These types of shipments have been carefully analyzed in the past, the potential environmental impacts found to be insignificant, and, as permitted under the Council on Environmental Quality's regulations concerning federal agency compliance with NEPA, have been categorically excluded from classes of specific actions which require detailed NEPA analysis by DOE's NEPA guidelines.

In regard to your concern with the transportation analysis contained in Chapter Nine of NUREG-0683, I would like to emphasize that NUREG-0683 did review the possible shipment of TMI-2 fuel by both rail and truck. While the written analysis contained in Chapter Nine focuses principally on truck transportation, it does so in reliance upon the earlier EIS (NUREG-0170) which concluded potential environmental impacts from shipments were directly related to the number of miles traveled by each shipment in a certified cask. For TMI fuel only 35-40 rail shipments will be needed, as opposed to approximately 250 truck shipments. Thus, the potential environmental impacts associated with these shipments are even fewer if rail transportation is used rather than truck transportation. Further, Appendix U of NUREG-0683 specifically analyzes the dose to the public from rail transportation.

The first shipment's compliance with the NRC Cask Certificate of Compliance (COC) is beyond question. The actual shipment period was a total of 34 days, in contrast to the up to 1000 days permitted by application of the requirements of the COC.

Finally the issues raised by Mr. Resnikoff as to the ability of the cask to handle extreme thermal burdens have been analyzed by DOE and determined to be without technical merit.

Enclosed you will find detailed discussion of the questions you raised regarding compliance with NEPA, the cask shipping window under the COC, safety-related elements and responses to the statements of Mr. Resnikoff regarding thermal burdens on the cask.

The health and safety of the public along the route is a prime concern of the fuel shipping program. The accident-resistant shipping cask in which the fuel is shipped is designed to retain the TMI-2 fuel even in a very severe accident. The TMI-2 fuel shipping program is a carefully monitored effort that complies with all applicable requirements.

If I can be of further assistance, please do not hesitate to contact me.

Yours truly,

Joseph F. Salgado
Under Secretary

Enclosures
As stated

cc: Honorable John Carlin
Governor of Kansas

Enclosure 1

Compliance with the National Environmental Policy Act (NEPA) of 1969 for TMI-2 Fuel Shipments

The Department of Energy (DOE) is required by NEPA to consider the environmental impacts of DOE actions, including the TMI-2 fuel shipments to the Idaho National Engineering Laboratory (INEL). The DOE reviews such actions in accordance with the Council on Environmental Quality (CEQ) regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (43 FR 55978) and DOE Guidelines for Compliance with the National Environmental Policy Act (45 FR 20694), as amended. In accordance with CEQ's regulations, the DOE NEPA guidelines list three classes of actions which are generally applicable to all of DOE's activities: (1) categorical exclusions; i.e., those which normally do not require either environmental assessments (EA's) or environmental impact statements (EIS's); (2) actions requiring EA's but not necessarily EIS's; and (3) actions which normally require EIS's.

Under the DOE guidelines for NEPA compliance, the DOE has concluded that the TMI-2 fuel shipments fall within a categorical exclusion in DOE's NEPA guidelines, namely, as "Actions that are substantially the same as other actions for which the environmental effects have already been assessed in a NEPA document and determined by DOE to be clearly insignificant and where such assessment is currently valid." Therefore, no new EA or EIS is required for the action. In reaching that conclusion, the DOE considered previous NEPA analyses for irradiated fuel shipments routinely transported by the DOE by various transportation modes and the analysis of environmental effects and risks of shipments of spent nuclear fuel by various transportation modes in the Final Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes, NUREG-0170.

In reviewing the NEPA determination that the TMI-2 fuel shipments are categorically excluded from the requirements for an EA or EIS under provisions of NEPA and DOE guidelines for compliance with NEPA, the DOE considered the findings in the Final Programmatic Environmental Impact Statement Related to Decontamination and Disposal of Radioactive Wastes Resulting from March 28, 1979, Accident--Three-Mile Island Nuclear Station, Unit 2, NUREG-0683, which specifically addressed the impacts on workers and the public related to the transportation of the TMI irradiated fuel by rail in Appendix U. It is the DOE's judgment that these findings support the DOE's categorical exclusion determination and that there is no new information that refutes the basic finding that the TMI-2 fuel shipments are environmentally insignificant.

Whereas there may be apprehension on the part of the public regarding TMI fuel shipments because of the considerable attention focused on that facility, the fact is these shipments have significantly less of a potential for an adverse environmental impact than other spent fuel shipments even assuming the remote possibility of a breach in the cask. This results from

2

(1) the TMI fuel having had a short (less than 100 full-power days) operating life which did not allow for buildup of fission products; (2) there has been a 7.5-year time for radioactive decay; (3) most of the gaseous fission products were released into the TMI-2 containment building during the accident; and (4) significant leaching of fission products occurred while at TMI when the fuel rods ruptured during the accident and water reached the pellets. Accordingly, the NRC, DOE, and their contractors have concluded that the TMI-2 fuel shipments are more than adequately bounded by existing documentation on the potential for environmental impacts.

Enclosure 2

Compliance with Nuclear Regulatory Commission (NRC) Requirements in the Certificate of Compliance (COC) No. 9200 for the Model 125-B Cask

The COC for the TMI-2 cask contains requirements to assure that, while the cask is sealed, material inside the cask will not generate hydrogen, oxygen, and other inflammable gases in quantities sufficient to create a combustible mixture. These requirements are necessary because the TMI-2 fuel may generate hydrogen and oxygen gases through a process called radiolysis.

The procedures for meeting these requirements for each cask consists of the following five steps:

1. The canister is loaded with fuel, closed, dewatered, purged with argon gas, and sealed.

2. The sealed canister is placed in storage and monitored for a sufficient time--at least 14 days--to determine a gas generation rate for both oxygen and hydrogen gases.

3. After that time has elapsed, a sample of the gas mixture in the canister is withdrawn and analyzed using a gas chromatograph to determine the gas generation ratė for that canister.

4. Using the gas generation rate, the time required for the gas mixture within the canister to reach a combustible level is calculated. One-half of the calculated time is established as the "expected shipment time." The "expected shipment time" starts to run when the canister is finally sealed prior to shipment, not when it is opened for intermediate monitoring of gas levels or when the material is loaded onto the carrier's vehicle.

5. Finally, seven canisters are loaded into the TMI-2 cask preparatory to shipment. The "expected shipment time" for the cask is controlled by the shortest value of the seven canisters loaded into the cask.

In the case of the first shipment from TMI to INEL, the time to reach one-half the flammability concentration for oxygen for each canister was not less than 153 days. Since the preshipment storage period for canisters at TMI after gas monitoring, repurging, and sealing was 29 days and transit time for the rail cask and its contents to INEL was 5 days for a total of 34 days, the time to accumulate one-half of the concentration of even one of the two gases needed for combustible mixture was not exceeded and, as noted above, both gases would be required to form such a mixture. The gas analysis further showed that the time to reach one-half the flammability concentration for hydrogen. For each canister which had the highest gas production rate, there would be several years available to safely make a shipment before reaching <u>one-half</u> the combustible gas concentration for hydrogen.

For the first shipment, the results obtained from analyzing the gas samples using a gas chromatograph showed the concentration of each gas was below the lower limit of detectability for this sensitive type of analytical equipment. The samples were taken after a storage period of at least 14 days. Although the actual gas concentrations were below detectability, the generation rates were calculated assuming the gas concentration was in fact at the lower limit of detectability as a worst-case assumption. Thus, the 2,000 days calculated as the expected shipment time is a conservative estimate of time available based on the accuracy of the information obtained on gas generation in canisters. The actual catalytic recombiner systems built into the canisters are designed to preclude any combustible mixture from occurring in individual canisters during handling and transport. However, as an added level of conservatism, no credit is taken in the analysis for when the recombiner reaches equilibrium conditions. In this condition, the canisters could be safety stored or shipped for an indefinite period of time. Similar catalysts have been in use successfully in nuclear reactor systems for over 20 years.

Enclosure 3

PUBLIC SAFETY AND THE TMI FUEL SHIPMENTS

The following outline describes the steps taken and approaches used by the Department of Energy (DOE) to ensure public safety in the transport of spent fuel from Unit 2 of the Three-Mile Island Nuclear Power Station (TMI-2) near Harrisburg, Pennsylvania, to the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. The DOE has consistently made extra efforts and gone beyond all legal requirements.

- o An accident-resistant shipping cask specifically for the TMI-2 fuel shipping program was designed, built, and is being used for transport of TMI-2 fuel. This cask consists of three individual barriers, all of which must be breached before a release of radioactive materials in the fuel could occur. The outer-most barrier is the outer containment vessel of the rail cask, which is made of a 2-inch thick external stainless steel shell, a 1-inch thick inner stainless steel shell, and a 4-inch layer of lead sandwiched between the two layers of stainless steel. The second barrier is a 1-inch thick stainless steel inner containment vessel within which is a massive structure of 1-inch thick stainless steel plates that support seven stainless steel tubes. The inner most barrier is the canister, of which seven are individually placed in the tubes of the second barrier. Each canister is constructed of 1/4-inch stainless steel and is an American Society of Mechanical Engineers code-stamped pressure vessel designed to withstand internal pressures of 150 pounds per square inch.

- o An experienced company was selected to supply the cask used to transport TMI fuel. Nuclear Packaging, Inc. (NuPac) of Federal Way, Washington, designed and fabricated the Model 125-B cask and has more than 10 years of experience in designing, fabricating, and obtaining approvals from the Nuclear Regulatory Commission (NRC) for packages used to transport radioactive materials throughout the United States. Previously, NuPac designed the Model T-3 spent fuel shipping cask for the DOE in accordance with the 10 CFR Part 71 regulations and assisted in obtaining the certification for the T-3 cask from the NRC. That experience was used effectively in designing, building, and obtaining certification for the Model 125-B cask for the TMI-2 fuel shipments.

- o Factored into the technical approach adopted in designing the Model 125-B cask were design considerations which assumed the worst-case loadings of fuel in each of seven canisters for radiation shielding (i.e., the maximum quantity of fission product isotopes), the worst-case geometrical configuration of canisters and contents during a severe train accident for criticality (i.e., the maximum quantity of fissile isotopes without considering fuel burnup or nonfuel materials in the spent fuel), and worst-case train accident (i.e., cask derailment including a severe impact followed by a puncture rod impact, then a severe fire and finally flooding with water.) In every respect a conservative bounding condition was assumed to describe the fuel and then used in safety analyses following the accident condition sequence. The accident sequence which must be considered to certify the cask as accident-resistant is in reality an addition of conservatism to the requirements. Even after incorporating these stringent criteria into the design of the cask and canisters, additional efforts were made to conclusively demonstrate the safety of the TMI-2 cask. Results from construction and drop-testing of a 1/4-scale model of the cask and drop-testing a full-scale canister together with a detailed computer analyses of structural, thermal, shielding, and criticality features of the cask were published in the Safety Analysis Report for the 125-B Cask Model. This report showed the rail cask will maintain integrity, protect against a criticality, and retain contents under worst-case accident conditions.

- Throughout the cleanup effort at TMI-2, the DOE has used casks certified by the NRC. The transportation of fuel from TMI to INEL is no exception. Early in the planning for transport of fuel from TMI to INEL, the DOE decided that the TMI-2 fuel cask would be certified by the NRC. In so doing, the NRC provided the DOE with an independent evaluation of the transportation package designed and built by NuPac. As a result, the Model 125-B Cask was designed, built and certified to requirements in 10 CFR Part 71. Requirements in 10 CFR 71 for an accident-resistant design for Type B casks have been developed over the past 30 years through rulemaking and public comment processes. The integrity of those regulations is demonstrated by the fact that during that period of time there have been no radioactive material releases whatsoever from Type B accident-resistant packages containing high-specific activity wastes or spent nuclear fuel.

- To clearly demonstrate the margins of safety designed into the Model 125-B cask, the DOE authorized the drop tests of a 1/4 scale model cask by the Transportation Technology Center of Sandia National Laboratories (TTC/SNL). The 1/4-scale cask model was subjected to five drop tests (three at various angles from 30 feet onto an unyielding surface and two from 40 inches onto a puncture pin), each of which imposed the severe impact forces on the package which must be considered under 10 CFR Part 71. It should be emphasized that those tests are <u>not</u> required for licensing but were performed to (a) verify the computer analysis, and (b) demonstrate conclusively the structural integrity of the package. Examinations of the 1/4-scale model after testing indicated that the 125-B cask behaved as predicted and successfully demonstrated having met the NRC requirements in 10 CFR Part 71.

- The TMI-2 fuel is contained in stainless steel canisters, which were designed by GPU Nuclear and its subcontractors according to a quality assurance plan approved by the NRC. Fabrication of each canister was accepted by GPU Nuclear's contractors, then GPU Nuclear, and finally by DOE before being loaded with fuel by GPU Nuclear. The DOE and its contractors participated in determining the design requirements for the canisters, one of which is that each canister must survive 30 years of submerged storage at the INEL.

- The ability of the canister to survive an accident was demonstrated by subjecting a full-scale canister to a series of four drop tests by Chemical Technology Division of Oak Ridge National Laboratory (ORNL). The four tests were from 30 feet in end on and side orientations which simulated the deceleration canisters would experience in the Model 125-B cask.

- Results of drop tests at SNL and ORNL were included in the Safety Analysis Report of the Model 125-B cask by NuPac. Before that Safety Analysis Report was submitted to the NRC, it was thoroughly reviewed by EG&G Idaho, Inc., and the TTC/SNL on behalf of the DOE.

- The two Model 125-B casks were fabricated according to a quality assurance plan approved by the NRC. As an added measure of quality assurance, the DOE, through its contractor EG&G Idaho, Inc., provided an inspector in residence at the fabrication facility and additional quality overview during the entire construction process, witnessing by signature many key fabrication steps. After completion of fabrication, the NRC performed a 100 percent inspection of nondestructive examination records for both casks. That inspection probably was the most comprehensive audit of the quality records for design and fabrication of a cask ever performed by the NRC.

- At TMI, filling canisters with fuel, preparing canisters for loading into the Model 125-B cask, and loading seven canisters into each cask are responsibilities of GPU Nuclear, owner/operator of the TMI-2. Those responsibilities are discharged according to a quality assurance plan approved by the NRC and under the cognizance of NRC inspectors in residence at TMI. Each responsibility is broken down into a series of discrete tasks which are, in turn, defined and described in detailed operating procedures. Each procedure is approved by the NRC before use by GPU Nuclear. That level of quality assurance by both GPU Nuclear and NRC ensures that stipulations specified in the Certificate of Compliance issued by NRC for the Model 125-B cask and requirements from the DOE are met before a loaded rail cask is certified ready for transport from TMI to the INEL. But, in addition EG&G Idaho acting on behalf of the DOE, also provides an overview of canister loading and preparation for shipping operations including implementation of a DOE-approved canister acceptance program designed to ensure the canisters are properly prepared for shipment, long-term storage and use in the DOE's TMI-2 Core Examination R&D Program.

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- At TMI, after seven canisters are loaded into the NuPac 125-B rail cask, containment components of the cask are closed and leak-tested sequentially to ensure that each level of the leak-tight containment provided by the cask functions as required. A leak-tight leak rate is only 10^{-7} atm-cm^3/s; i.e., a ping-pong ball quantity of gas or less would leak from the cask in 1 year. Once the cask is closed entirely and passed the leak tests, it is returned to its railcar, equipped with its overpacks, inspected for proper assembly and attachment to the railcar, surveyed radiologically, and certified ready for transport by GPU Nuclear. At this point, the cask is inspected again by an inspector of the NRC who conducts a radiological survey of the package and inspects accompanying documentation, ensuring that radiation levels around the cask meet limits specified by the Department of Transportation and NRC.

- Following the inspection by the NRC, another confirmation that everything is in order is performed by a representative of the DOE, before the DOE accepts title to the cask and contents. But, in addition, before the package leaves TMI, it is inspected by a representative of the Federal Railroad Administration, who reviews documentation and examines the railcar, cask, and attachments. Once that inspection is complete, the rail carrier inspects the package, the environmental cover is placed over the cask, and the cask is accepted for transport.

  It is worth noting that radiation levels at the surface of the first cask which left TMI in July were less than 2.5 mr/hr. That is much less than the 200 mr/hr at the surface permitted by the Department of Transportation. After transport of that cask from TMI to the INEL, representatives of the DOE monitored the cask and found no change in external levels of radiation.

- After the rail route between TMI and the INEL was selected, the Federal Railroad Administration inspected tracks of the entire route and issued an approval for use by the Model 125-B cask. In addition, Conrail performed a detailed examination of the tracks between TMI and the switchyard in East St. Louis, Illinois. Likewise Union Pacific Railroad performed a detailed examination of trackage between East St. Louis and the boundary of the INEL west of Idaho Falls, Idaho. The tracks are of the highest quality and under continuous surveillance by the carriers involved.

- The railcars used in these shipments are special eight-axle heavy-duty cars selected by DOE at extra cost to provide a wide margin of safety; the cars are rated for 165-ton loads, whereas the loaded cask nominally is 115 tons. A maintenance agreement was authorized by DOE with the Union Pacific Railroad to perform car inspection and maintenance every trip.

Enclosure 4

Responses to Sierra Club Newsletter
Analysis of the Model 125-B TMI Shipping Cask

The Sierra Club issued a newsletter entitled Analysis of Model 125-B TMI Shipping Cask on July 8, 1986, raising several questions relative to the suitability of the cask design to safely perform its intended function when exposed to severe accident conditions. The thrust of the newsletter deals with the thermal aspects of the regulatory requirements for Type B packaging and, specifically, the ability of the 125-B shipping cask to adequately protect the public in the event of a thermally abusing accident. This enclosure responds to the newsletter's allegations dealing with thermal burdens imposed on the cask design.

Allegation: "Material will not be shipped in the Model 125-B container 'dry'. The fuel pellets would be placed in containers, seven to a cask, the total package, cask, containers and fuel, weighing approximately 90 tons. Each container will hold considerable water. In the case of a long-duration fire, pressures can build within the containers and the cask, causing the safety valve, or rupture disk, to fail. Unlike fuel in fuel assemblies, which are contained within fuel rods, the fission products could directly mix with steam and be released from the cask."

Response: The Model 125-B cask was designed to transport wet fuel debris and meets or exceeds all regulatory requirements for such shipments. In-depth thermal analysis shows the canister internal temperatures will reach only 180°F when exposed to the regulatory required thermal environment. This temperature is sufficient for generating only moderately hot water and is certainly insufficient for generating enough steam to cause canister overpressurization. The canisters are, in fact, designed for pressures up to 150 psig and tested to 125 percent of this design, which would require internal temperatures of 365°F for the internal water-steam mixture to reach the canister's design pressure. This temperature is more than twice that anticipated when exposing the package to an integrated thermal environment matching the regulatory requirements.

The Model 125-B cask is composed of two independent containment systems in addition to the fuel debris canisters. Each of these cask containment systems is designed for internal pressures up to 300 psig and contains a pressure relief device (rupture disc) to prevent the uncontrolled buildup of pressure in either cask cavity beyond the 300 psig design value as an added margin of safety. For steam to be released from the assembled package, all three levels of containment would have to be breached, starting with the canisters and working outward through each successive containment barrier. Both the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) have concluded that the design basis thermal environment (discussed in the next allegation) reasonably bounds the maximum internal pressures within the cask components and none of the containment boundaries should exceed their design specifications.

Allegation: One allegation challenges the adequacy of the regulations, stating that the regulatory fire conditions of 1475°F for 1/2-hour, "are not the most severe accident conditions that have been or could be encountered by rail." It goes on to say "Under real (vs. IAEA hypothetical) fire conditions, the temperature of the canister would easily exceed 212°F."

Response: The regulations covering the shipment of spent fuel in the United States were first established in 1948 by the National Academy of Sciences and were later adopted by the International Atomic Energy Agency (IAEA). The regulations have been subjected to periodic exhaustive reexamination because of similar allegations and additional information. However, because of the technical basis and expertise of the original drafters and the extreme conservatism used, few changes have been made during the intervening 38 years.

While the Sierra Club allegation mentions fire temperatures and duration, they fail to mention other important factors that must be considered to calculate accurately the effects of fire on the cask. These factors include: (1) the amount of cask surface exposed to the fire; (2) radiant heat transfer characteristics of the fire (technically, the emissivity of the fire); and (3) the ability of the cask to absorb heat (surface absorptivity). These factors are included in the calculations in the Safety Analysis Report (SAR); and these calculations, performed on a conservative basis, clearly show that internal canister temperatures would not exceed 180°F when the cask is exposed to the regulatory design basis thermal environment.

Because of conditions imposed by the regulations, the thermal environment (1475°F for 1/2-hour) is equivalent to a much hotter, longer-duration fire. For example, one of the conditions imposed by the regulations is for total cask immersion. For this condition to exist, the cask would need to be suspended well above the lower surface of the fire (a highly unlikely event, considering the 90 tons of immense weight of the cask). Also, in spite of the fact that some materials burn at higher temperatures, they do not radiate at their adiabatic (theoretical) temperatures. Further, if the fire is not sufficiently thick, the cask can radiate heat back through the flames, thus mitigating the heat-transfer effects of the fire. According to a recent Sandia National Laboratories study, the Caldecott tunnel fire (cited in the Sierra Club allegation) which burned for 1 3/4-hours, reaching temperatures of 1900°F for at least 20 minutes, "approximately matched the thermal input required in the current regulations." Considering the fact that margins of safety are inherent in the regulations and that the Model 125B cask exceeds the regulatory requirements with additional margins by a significant amount, the cask is judged to exceed the minimum safety requirements.

Allegation: "Calculations by G.E. for the IF-300 cask show that pressure would exceed 300 psig due to the contained water."

Response: No connection between IF-300 cask performance and the Sierra Club analysis of the Model 125-B cask is made. The statement appears to have no relationship with Model 125-B cask safety.

Allegation: "The cask contains a thermal shield, a relatively thin stainless steel skin containing water. The thermal shield protects against neutrons, which is not a problem with low burnup TMI fuel. This thin shield would be immediately ruptured in an accident. Contrary to the NRC analysis, the thermal shield should not be counted on to prevent lead melting and thermal degradation of closure seals and BISCO moderators."

Response: The Model 125-B cask does have a thermal shield around the outer circumference of the outer cask. It consists of an annular air gap, nominally 0.106 inches thick, covered by a 10-gauge (0.134 inches thick) stainless steel cylinder. Contrary to the allegation, there is no water in the thermal shield. Also contrary to their statement, the shield has nothing to do with shielding against neutrons; its only purpose is to provide additional thermal protection for the massive cask. The stainless steel shell provides reflective insulation and the air gap provides conductive insulation.

Regarding the last point in this allegation, the thermal analysis documented in the SAR did assume the shield would be ruptured during the puncture pin accident required to be considered by the regulations. In fact, the amount of rupture assumed for the thermal analyses exceeded the amount experienced in the drop test program, adding to the conservatism of the calculations and the safety margin.

Allegation. "Several components of the shipping cask are "thermally-sensitive," including the Neoprene O-rings used to seal the cask (230°F), the BISCO neutron moderators (220°F) and the polyurethane foam overpacks (150°F). In fact, it would be surprising if the foam impact limiters did not shrink solely due to the sun heating the stainless steel skin. While the thermal insulation might not be affected because of the air pockets, the ability to absorb impact, however, would. In their rush to certify the shipping cask, the NRC did not verify whether the impact limiters would be so affected."

Response: The recommended operating range for Neoprene seals is, in fact, 250°F, not 230°F; and for the BISCO neutron moderators it is 250°F, not 220°F. Further, as documented in the SAR, exposure of the cask to the specified accident regulatory thermal environment indicated the maximum temperature for the Neoprene seals would be 228°F in the outer vessel and 134°F in the inner vessel. Maximum temperature of the BISCO neutron moderator would be 192°F. All of these temperatures are well within the recommended operating ranges for these materials. Furthermore, these materials can withstand much higher temperatures (500°F for the Neoprene seals) for short durations such as a fire transient.

Regarding the foam impact limiters, those limiters do not shrink as a result of solar heating. The recommended operating range of the foam utilized in the overpacks is from -20°F to 150°F and from the SAR, the highest calculated temperature from solar heating would be 135°F. Also, as clearly shown in the cask SAR, the energy-absorbing capability of the foam overpacks increases as temperatures increase. All of this information was provided to the NRC in the SAR submittal.

Allegation: "The BISCO moderators separate the seven canisters and hold the cask contents subcritical. In a long duration fire, the moderators could melt. If the cask interior was dry, no nuclear reaction would take place. However, if following a fire and destruction of the rupture disks, the cask rolled into water, serious consequences could ensue since the TMI fuel is only 10% used. In this case, the cask would cool, water would enter, and a nuclear reaction would begin. Water would then heat up and be expelled, shutting down the reaction. Water would enter and the reaction would restart. This pulsing phenomenon would continue for several years, each time emitting radioactivity. The consequences of this type of admittedly remote accidents are sufficiently great that the NRC should ensure that the cask and containers are absolutely dry so that the rupture disk does not fail. It may be preferable to install pressure relief valves."

Response: The Model 125B inner containment vessel (ICV) contains two forms of BISCO, NS-3 and NS-4. During fabrication of the cask, solid blocks of NS-4 are placed alongside the structural components of the ICV. NS-3, in liquid form, is pumped into the remaining voids and then solidifies into a concrete-like substance. This process adds rigidity to the structure and provides the necessary neutron-absorption capabilities. NS-3 is a fire-resistant material and, in fact, is recommended for use in vaults as a high-temperature criticality control material. NS-4 is rated for continuous use at temperatures up to 250°F and is thermally stable up to 400°F for short durations. Both of these materials are rated for temperatures well above those calculated for the ICV and would not melt even in more extreme fire conditions. Therefore, the pulsing scenario described above is not a credible scenario.

UNITARIAN
UNIVERSALIST
SERVICE
COMMITTEE
of KANSAS

1176 Warren, Topeka, Kansas
66604

July 28, 1986

Governor Carlin
2nd Floor, State Capitol
Topeka, Ks. 66612

Dear Governor Carlin,

I'm writing with concern about the transportation of the Three Mile Island damaged nuclear fuel assemblies through the northeast section of Kansas. I observed the TMI train as it passed through North Topeka about 6:40 P.M. on July 22nd. For me the passing of this train raised many questions, particularly in regards to public safety. Realizing my lack of factual information, I have acquired from DOE various publications that deal specifically with the safety of the TMI train.

Via this information some questions have been answered, but other safety questions come to mind. Some of these questions are technical, while others deal with the logistics of moving the train through highly populated areas such as Kansas City, Lawrence,Topeka, etc.

I realize that the DOE, the NRC, the DOT and the Union Pacific Railroad have taken measures to make these shipments as safe as possible. However, I believe that the seriousness of a possible accident demands that a small group of Kansans, hopefully with representatives from Union Pacific and DOE, meet in the near future. I think the agenda for this meeting should include:

1)sharing of information and answering technical and logistical questions
2)discussion of alternative routes
3)possible safety measures to be taken at the local level, if and when necessary
4)and other safety related issues

I'm writing a similar letter to Rep. Slattery. Perhaps a jointly sponsored meeting could be arranged.

The July 22nd shipment was the first TMI train to come through Kansas. There are approximately 35 to 40 more shipments yet to come. Let us address this public safety issue as unified Kansans.

Sincerely,
Les J. Davis
Les J. Davis
Unitarian Universalist Service Committee

cc:Senator Kassebaum
Senator Dole
John E. Bromley
Union Pacific
Terry Smith of DOE at TMI

Department of Energy
Washington, DC 20585

Ms. Carma Potter
P. O. Box 8422
Moscow, Idaho 83843

Dear Ms. Potter:

Congressman Larry Craig has requested the Department of Energy to respond to your letter concerning the storage of the Three Mile Island (TMI) reactor fuel at the Idaho National Engineering Laboratory (INEL).

Let me assure you that the Department of Energy does not plan to dispose of the TMI fuel at the INEL. Portions of the fuel will be examined by scientists and engineers at the INEL studying the TMI accident. Following completion of these studies and upon availability of a Federal high-level waste repository in the late 1990's, the fuel will be shipped from Idaho to the repository for disposal. Since the fuel will remain inside a building at all times and will be carefully monitored, it poses no threat to the Snake River aquifer.

INEL was selected to perform the tests on the TMI fuel because it is the Department of Energy facility specifically dedicated to studying nuclear reactor safety and has experience, personnel, and internal facilities to study reactor systems and core components. These facilities and capabilities are unique.

I hope that this information responds to your concerns. Public information personnel at the INEL will be sending you an information package on the TMI fuel shipments and radioactive waste handling at the INEL. Thank you for your interest in our program.

Sincerely,

Original signed by

A. David Rossin
Assistant Secretary
for Nuclear Energy

cc:
Honorable Larry E. Craig
House of Representatives
Washington, D.C. 20515

bcc:
T. Smith, EG&G
R. Schmitt, EG&G

Liz Paul
P.O. Box 2660
Ketchum, ID 83340

Mr. Terry Smith
EG&G Idaho Inc.
P.O.Box 88
Middletown, PA 17057

July 21, 1986

Dear Mr. Smith,

I have a number of questions concerning the transfer of core debris from TMI-2 to INEL.

1. When was the decision made to move the core to INEL? Please give me information as to why this decision was made and how it was made as well. Was there a supplement to the final EIS which addressed this decision?

2. What is the nature of the agreement between the NRC and the DOE concerning the transfer of the core from one agency to the other? In the EIS there was doubt that the DOE would take the TMI-2 fuel. What made them change their mind?

3. The EIS mentions possible reprocessing of the fuel. Is this still a possibility? Is the fuel still classified as comercial even though the DOE "owns" it once it leaves TMI? Does the ICPP have the capacity to reprocess the TMI-2 fuel? Does PUREX? Are there plans to modify either of these facilities to enable them to reprocess the TMI-2 fuel?

4. What are the long term plans for the core? What contingency plans does the DOE have if a reposiitory is not built? INEL has never been a candidate for high level waste storage because it is not a suitable site. Isn't it dangerous to store the fuel at INEL?

5. Please outline the research program that will be carried out with the fuel at INEL

6. What, if any, measures are being taken to ensure a safe arrival at INEL of the fuel? Will local police and emergency crews be notified of the shipments? Will residents be informed of the shipments? If not please explain.

Thank you for time. Please contact me if there are any problems concerning my questions.

Sincerely,

Liz Paul

INEL
Idaho National Engineering Laboratory

September 24, 1986

Ms. Liz Paul
P.O. Box 2660
Ketchum, ID 83340

REQUEST FOR INFORMATION ON TMI-2 FUEL - TAS-20-86

Ref: L. Paul ltr to T. A. Smith requesting information regarding the TMI-2 fuel, July 21, 1986.

Dear Ms. Paul:

Thank you for your letter regarding the core materials being received at the Idaho National Engineering Laboratory (INEL) from the Three Mile Island Unit 2 reactor (TMI-2) near Middletown, Pennsylvania. The referenced letter listed six sets of questions for which you requested answers. I hope the responses listed below satisfy your request. To avoid redundancy, the responses to some questions have been combined since the issues are closely related.

Question 1. When was the decision made to move the core to INEL? Please give me information as to why this decision was made and how it was made as well. Was there a supplement to the final EIS which addressed this decision?

Question 2. What is the nature of the agreement between the NRC and the DOE concerning the transfer of the core from one agency to the other? In the EIS there was doubt that the DOE would take the TMI-2 fuel. What made them change their mind?

Response 1&2. In the Final Programmatic Environmental Impact Statement (NUREG-0683) prepared by the Nuclear Regulatory Commission (NRC) on the TMI-2 accident and issued in March 1981, there appears in Chapter 9 (Storage, Transportation, and Disposal of Fuel and Solid Waste) a lengthy discussion and environmental analysis of packaging and transporting nuclear debris from TMI to various commercial and federally owned installations around the U.S. The NRC noted that for high specific activity nuclear wastes there are commercial facilities around the country which could handle or dispose such materials, but none that could do both simultaneously. Moreover, none could accommodate core debris from the TMI-2. Therefore, NRC concluded that the Department of Energy (DOE) through its contractors and laboratories "...appears to have the only suitable combination of established personnel, technological capabilities, and interests..." for research, processing, and disposing all nuclear materials from

TMI-2. Accompanying that discussion and analysis are maps detailing routes between TMI and possible terminal destinations. Among those maps are two detailing directions to the INEL. Additionally, in Appendix U an impact analysis was completed comparing truck and rail shipments which fully bounds the consequences of the TMI-2 fuel shipments.

Shortly after issuance of the PEIS, NRC and DOE signed a Memorandum of Understanding in July 1981 which established an agreement that DOE would transport, receive, research, store, process or repackage, and dispose of nuclear waste not acceptable at operating commercial low-level waste disposal facilities. The following March (1982), NRC and DOE revised and cosigned the Memorandum of Understanding to reflect DOE's acceptance of the TMI-2 core for research and storage at the INEL. Those agreements are consistent with discussions in the PEIS and charter and mission of the INEL, which for three and one half decades has been studying behavior of nuclear reactors and developing safety codes for predicting operations during nuclear transients.

Because NRC outlined the strategy for recovery of TMI-2 and the long-term management of nuclear materials from the accident in the PEIS, because DOE was a reviewer and commenter on the draft PEIS distributed to the public and governmental agencies and organizations, and because NRC and DOE cosigned the Memorandum of Understanding shortly after issuance of the PEIS, additional environmental documentation regarding decisions for management and disposition of nuclear materials from TMI-2 was obviated.

Question 3. The EIS mentions possible reprocessing of the fuel. Is this still a possibility? Is the fuel still classified as commercial even though the DOE "owns" it once it leaves TMI? Does the ICPP have the capacity to reprocess the TMI-2 fuel? Does PUREX? Are there plans to modify either of these facilities to enable them to reprocess the TMI-2 fuel?

Response 3. As you may be aware, in 1977 President Carter by Executive Order halted all processing of commercial nuclear fuel in the U.S. Processing of nuclear fuel in the sense of that Executive Order is purposed toward recovery of usable nuclear fuel. Reference in the PEIS to processing the TMI-2 fuel is most likely intended toward transformation of the material into a form suitable for disposal at a national repository, rather than processing for recovery of usable fuel.

While it might be technically feasible to process the TMI-2 fuel at either the Idaho Chemical Processing Plant or PUREX, DOE's current plan is to place the TMI-2 fuel in the national repository once the national repository is in place and the TMI-2 Accident Evaluation Program has completed examination of the material.

Question 4. What are the long term plans for the core? What contingency plans does the DOE have if a repository is not built? INEL has never been a candidate for high level waste storage because it is not a suitable site. Isn't it dangerous to store the fuel at the INEL?

Response 4. As stated in the previous response, DOE's current plan is to place the TMI-2 fuel in the national repository. Storage of the TMI-2 fuel at the INEL is planned for up to 30 years. Based upon the mandate in the Nuclear Waste Policy Act, the probability is high of having a national repository completed within the next 30 years.

Safe storage of the TMI-2 fuel is provided at the INEL Test Area North (TAN) Hot Shop facility where the material is delivered upon arrival at the INEL. At the TAN Hot Shop, the loaded fuel canisters are removed from the shipping casks and placed in underwater storage bins inside the Hot Shop facility. The TAN Hot Shop provides complete containment from the environment.

Question 5. Please outline the research program that will be carried out with the fuel at the INEL.

Response 5. The core examination work being performed in the DOE program is outlined in the enclosed document: EGG-TMI-7048 - TMI-2 Accident Evaluation Program.

Question 6. What, if any, measures are being taken to ensure a safe arrival at INEL of the fuel? Will local police and emergency crews be notified of the shipments? Will residents be informed of the shipments? If not please explain.

Response 6. The safety of the public always has been and continues to be the highest priority in the TMI-2 fuel debris transport program. The safety of the public is ensured first and foremost by the strong leaktight cask in which the material is shipped. Typical of other spent fuel shipping casks, the NuPac 125B for the TMI-2 core material is certified by the NRC and designed to withstand a series of hypothetical accident conditions which simulate a very severe transportation accident. To clearly and unquestionably demonstrate the ability of the TMI-2 cask to withstand severe impacts during transportation accidents, a scale model was built and drop-tested in a program which was not required by 10CFR71 regulations but which does provide an easily understood, visual record of the durability of the TMI-2 cask.

Another element in the DOE plan to safely transport the TMI-2 fuel debris is to ensure that the best tracks and shortest transport time reasonably available are used. These criteria are in accordance with Department of Transportation (DOT) guidelines to minimize time in transit, use excellent track, avoid high densities when possible, and accomplish the shipments with the fewest switches between rail carriers. In following these guidelines, the rail carriers and the DOE selected a route that accomplishes the shipments in four-five days, uses the highest quality track available and involves only one carrier change, between Conrail and Union Pacific in East St. Louis, Illinois. Although routing is thoroughly considered in transferring radioactive materials, it is only a secondary safety factor, with primary safety being provided to the public and the environment by cask integrity.

Each segment of transportation for the TMI-2 shipments will comply with applicable regulations of the DOT, which regulates shipments under the authority of the Hazardous Materials Transportation Act. DOT has established extensive safety regulations for radioactive materials transport, including, but not limited to, requirements for inspections, packaging, monitoring, training, security and reporting. In the more than 40 years of transporting radioactive materials across the U.S. an exemplary record of safety has been achieved. Although there is public apprehension about shipping spent fuel, there has never been an injury or death attributable to radiation as a result of an accident involving transportation of radioactive materials.

As a further commitment to public safety, the DOE selected rail carriers with extensive experience in handling hazardous materials. The Union Pacific Railroad hauls more hazardous material than any other land-based carrier in the U.S., and Conrail is also a major carrier of such materials. Both Conrail and Union Pacific have maintained high safety records. Union Pacific won the coveted 1985 Harriman Safety Award, which honors the rail carrier with the top safety record in the industry. In the last 20 years, Union Pacific has won this award 17 times, a record of achievement which demonstrates Union Pacific's commitment to safety.

As further safety precautions: a) the Federal Railroad Administration (FRA) has inspected the entire route used for these shipments and the rail carriers conduct routine inspections to ensure the high quality of the tracks; b) the TMI-2 shipments are routinely inspected before shipment by DOE, NRC, DOT and FRA officials; c) the railcars are maintained each trip through a maintenance contract with Union Pacific; d) some of the states are monitoring shipments en route in support of local emergency response efforts; and e) radiological and vehicular inspections are conducted at the destination facility at the INEL.

Regarding notifications, DOE has developed a procedure by which it notifies the governor's designee in each state along the route with scheduling and shipping information. The governors' designees have the authority to release this information to other state or local officials on a need-to-know basis. Scheduling information is not released publicly to preclude interference of any kind with the shipments.

DOE also has in place an emergency response network controlled by the Warning Communications Center (WCC) at the INEL. The WCC is responsible for coordinating all activities, including notification of state officials and emergency response teams in the unlikely event that an accident occurs.

Thank you for your patience in waiting for responses to these questions. Please contact me if I can be of further assistance.

Very truly yours,

Terry A. Smith
Public Information Office

le

Enclosure:
As Stated

cc: P. D. Grimm, DOE-DP
D. J. McGoff, DOE-NE
P. Mygatt, DOE-ID
W. R. Young, DOE-TMI
J. O. Zane, EG&G Idaho

INEL
Idaho National Engineering Laboratory

L. J. Ball
J. M. Broughton
W. A. Franz
P. J. Grant
S. Langer
R. K. McCardell
H. W. Reno
R. C. Schmitt
D. L. Uhl
J. M. Wilson
Central Files

October 7, 1986

Ann Marie McDonough
Council on Economic Priorities
Floor 9
30 Irving Place
New York, NY 10003

REQUEST FOR DOCUMENT AND VIDEO ON TMI-2 FUEL SHIPMENTS - TAS-21-86

Dear Ms. McDonough:

Regarding our telephone conversations of September 25, 1986 and October 2, 1986, enclosed is the report TMI-2 Accident Evaluation Program, EGG-TMI-7048, which I believe will satisfy your request for a document detailing research to be performed on the Three Mile Island Unit 2 (TMI-2) fuel material at the Department of Energy's Idaho National Engineering Laboratory (INEL).

You also requested a VHS format video tape describing the TMI-2 fuel shipping program. Per your request, an eight-minute video is being mailed to you separately from our office at TMI.

Thank you for your interest in the TMI-2 fuel shipping program. Please contact me if I can be of further assistance.

Very truly yours

Terry A. Smith
Public Information Office

ka

Enclosure:
As Stated

cc: P. D. Grimm, DOE-DP
D. J. McGoff, DOE-NE
P. Mygatt, DOE-ID
W. R. Young, DOE-TMI
J. O. Zane, EG&G Idaho

EG&G Idaho, Inc. P.O. Box 1625 Idaho Falls, ID 83415

Idaho National Engineering Laboratory

W. A. Franz
P. J. Grant
R. C. Schmitt
T. A. Smith
D. L. Uhl
Central Files

OCT

October 2, 1986

Ms. Karen Kelley
KETV-ABC
27th and Douglas St.
Omaha, NE 68131

REQUEST FOR FILE FOOTAGE ON TMI-2 FUEL SHIPMENTS - JMW-227-86

Dear Ms. Kelley:

Thank you for your interest in the Three Mile Island Unit 2 (TMI-2) fuel shipping program. Per our recent telephone conversation, a video tape for your use is being mailed to you from our office at TMI. The video tape contains about six minutes of file footage showing arrival of the first shipment of TMI-2 fuel at the Idaho National Engineering Laboratory (INEL), unloading procedures of the cask from the railcar, transport of the cask to the INEL Test Area North (TAN), and unloading of cask and fuel canisters in the TAN Hot Shop Facility.

I hope this satisfies your request for file footage of shipment arrival at the INEL. Please contact me if I can be of further assistance.

Very truly yours

Janine M Wilson

Janine M. Wilson, Manager
Public and Employee Communications

TAS:ka

cc: P. Mygatt, DOE-ID
W. R. Young, DOE-TMI
J. O. Zane, EG&G Idaho

EG&G Idaho Inc P.O. Box 1625 Idaho Falls, ID 83415

United States Senate

WASHINGTON, D.C. 20510

December 3, 1986

The Honorable John S. Herrington
Secretary, U.S. Department of Energy
James Forrestal Building
1000 Independence Avenue S.W.
Washington, D.C. 20585

Dear Secretary Herrington:

We have received the enclosed letter from Victoria Champion of Danville, Indiana, regarding the shipment of nuclear wastes through Indiana. We would appreciate your review and written response to this letter.

Should you have questions or concerns regarding this correspondence, please feel free to contact us at Room 447, 46 East Ohio Street, Indianapolis, Indiana 46204, attention Mark G. Ahearn, (317)269-5555 or FTS 331-5555. Your assistance is appreciated.

Sincerely,

Richard G. Lugar
United States Senator

Sincerely,

Dan Quayle
United States Senator

Enclosure

JAN 14 1987

Honorable Dan Quayle
United States Senate
46 East Ohio Street
Indianapolis, Indiana 46204

Dear Senator Quayle:

Thank you for your letter of December 3, 1986, to Secretary of Energy John S. Herrington regarding the shipments of spent nuclear fuel from the Three-Mile Island (TMI) facility. As the organization within the Department of Energy (DOE) responsible for transportation of radioactive materials, your letter was sent to me for a reply.

We understand the concern the public has about these shipments and we share a mutual goal of providing for the health and safety of all citizens and the protection of the environment. Please be assured we use extreme care in all our transportation activities.

Enclosed for your information are some fact sheets describing in detail the extraordinary safety precautions being taken on spent fuel shipments. This information specifically addresses Ms. Champion's question on radiation levels.

The shipment of hazardous materials is strictly regulated by the Department of Transportation. Packaging and transportation regulations for radioactive materials are established and enforced by specific regulations (49 CFR 100-177). Separate railroad safety requirements have also been established by the Federal Railroad Administration.

In the more than 40 years of transporting radioactive materials across the United States, we have achieved an exemplary safety record. Although there is public apprehension about shipping spent fuel there has never been an injury or death attributable to radiation as a result of an accident involving its transportation.

I hope this information will be helpful to your constituent. We appreciate the opportunity to respond to your inquiry.

Sincerely,

(signed)

John L. Meinhardt
Deputy Assistant Secretary
for Nuclear Materials
~~Defense Programs~~

4 Enclosures

cc:
Honorable Dan Quayle
United States Senate
Washington, DC 20510

Distribution:
so: Addressee
4bcc: ES (ES86-017997/Due:12-30-86) w/orig. incmg & ticket
1bcc: CP-30 w/copy ticket & incmg
1bcc: CP-1
2bcc: DP/MR
1bcc: DP-1
2bcc: DP-12
1bcc: DP-121 Rdr
1bcc: Originator
1bcc: DP-12 Suspense
1bcc: DP-10 Suspense
1bcc: EH-1
1bcc: NE-1

DP-121:PGrimm:ksm:353-3506:1-2-87:WANG2301o

Correspondence Reviewer: G. Payne
DP Control Number: DP-86-008034

Identical response sent to:
Honorable Richard G. Lugar
United States Senate
46 East Ohio Street
Indianapolis, Indiana 46204

CONCURRENCES

RTG SYMBOL	INITIALS/SIG.	DATE
DP-121	PGrimm	1-5-87
DP-121	LHanson	1-5-87
DP-12	THindman	1-5-87
DP-12	Little	1-6-87
DP-10	JMeinhar	1- -87
CP-30		1- -87

DOE F 1325.10
(7-79)

OFFICIAL FILE COPY

PUBLIC SAFETY AND THE TMI FUEL SHIPMENTS

The following outline describes the steps taken and approaches used by the Department of Energy (DOE) to ensure public safety in the transport of spent fuel from Unit 2 of the Three-Mile Island Nuclear Power Station (TMI-2) near Harrisburg, Pennsylvania, to the Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho. The DOE has consistently made extra efforts and gone beyond all legal requirements.

- o An accident-resistant shipping cask specifically for the TMI-2 fuel shipping program was designed, built, and is being used for transport of TMI-2 fuel. This cask consists of three individual barriers, all of which must be breached before a release of radioactive materials in the fuel could occur. The outer-most barrier is the outer containment vessel of the rail cask, which is made of a 2-inch thick external stainless steel shell, a 1-inch thick inner stainless steel shell, and a 4-inch layer of lead sandwiched between the two layers of stainless steel. The second barrier is a 1-inch thick stainless steel inner containment vessel within which is a massive structure of 1-inch thick stainless steel plates that support seven stainless steel tubes. The inner most barrier is the canister, of which seven are individually placed in the tubes of the second barrier. Each canister is constructed of 1/4-inch stainless steel and is an American Society of Mechanical Engineers code-stamped pressure vessel designed to withstand internal pressures of 150 pounds per square inch.

- o An experienced company was selected to supply the cask used to transport TMI fuel. Nuclear Packaging, Inc. (NuPac) of Federal Way, Washington, designed and fabricated the Model 125-B cask and has more than 10 years of experience in designing, fabricating, and obtaining approvals from the Nuclear Regulatory Commission (NRC) for packages used to transport radioactive materials throughout the United States. Previously, NuPac designed the Model T-3 spent fuel shipping cask for the DOE in accordance with the 10 CFR Part 71 regulations and assisted in obtaining the certification for the T-3 cask from the NRC. That experience was used effectively in designing, building, and obtaining certification for the Model 125-B cask for the TMI-2 fuel shipments.

- o Factored into the technical approach adopted in designing the Model 125-B cask were design considerations which assumed the worst-case loadings of fuel in each of seven canisters for radiation shielding (i.e., the maximum quantity of fission product isotopes), the worst-case geometrical configuration of canisters and contents during a severe train accident for criticality (i.e., the maximum quantity of fissile isotopes without considering fuel burnup or nonfuel materials in the spent fuel), and worst-case train accident (i.e., cask derailment including a severe impact followed by a puncture rod impact, then a severe fire and finally flooding with water.) In every respect a conservative bounding condition was assumed to describe the fuel and then used in safety analyses following the accident condition sequence. The accident sequence which must be considered to certify the cask as accident-resistant is in reality an addition of conservatism to the requirements. Even after incorporating these stringent criteria into the design of the cask and canisters, additional efforts were made to conclusively demonstrate the safety of the TMI-2 cask. Results from construction and drop-testing of a 1/4-scale model of the cask and drop-testing a full-scale canister together with a detailed computer analyses of structural, thermal, shielding, and criticality features of the cask were published in the Safety Analysis Report for the 125-B Cask Model. This report showed the rail cask will maintain integrity, protect against a criticality, and retain contents under worst-case accident conditions.

- Throughout the cleanup effort at TMI-2, the DOE has used casks certified by the NRC. The transportation of fuel from TMI to INEL is no exception. Early in the planning for transport of fuel from TMI to INEL, the DOE decided that the TMI-2 fuel cask would be certified by the NRC. In so doing, the NRC provided the DOE with an independent evaluation of the transportation package designed and built by NuPac. As a result, the Model 125-B Cask was designed, built and certified to requirements in 10 CFR Part 71. Requirements in 10 CFR 71 for an accident-resistant design for Type B casks have been developed over the past 30 years through rulemaking and public comment processes. The integrity of those regulations is demonstrated by the fact that during that period of time there have been no radioactive material releases whatsoever from Type B accident-resistant packages containing high-specific activity wastes or spent nuclear fuel.

- To clearly demonstrate the margins of safety designed into the Model 125-B cask, the DOE authorized the drop tests of a 1/4 scale model cask by the Transportation Technology Center of Sandia National Laboratories (TTC/SNL). The 1/4-scale cask model was subjected to five drop tests (three at various angles from 30 feet onto an unyielding surface and two from 40 inches onto a puncture pin), each of which imposed the severe impact forces on the package which must be considered under 10 CFR Part 71. It should be emphasized that those tests are <u>not</u> required for licensing but were performed to (a) verify the computer analysis, and (b) demonstrate conclusively the structural integrity of the package. Examinations of the 1/4-scale model after testing indicated that the 125-B cask behaved as predicted and successfully demonstrated having met the NRC requirements in 10 CFR Part 71.

- The TMI-2 fuel is contained in stainless steel canisters, which were designed by GPU Nuclear and its subcontractors according to a quality assurance plan approved by the NRC. Fabrication of each canister was accepted by GPU Nuclear's contractors, then GPU Nuclear, and finally by DOE before being loaded with fuel by GPU Nuclear. The DOE and its contractors participated in determining the design requirements for the canisters, one of which is that each canister must survive 30 years of submerged storage at the INEL.

- The ability of the canister to survive an accident was demonstrated by subjecting a full-scale canister to a series of four drop tests by Chemical Technology Division of Oak Ridge National Laboratory (ORNL). The four tests were from 30 feet in end on and side orientations which simulated the deceleration canisters would experience in the Model 125-B cask.

- Results of drop tests at SNL and ORNL were included in the Safety Analysis Report of the Model 125-B cask by NuPac. Before that Safety Analysis Report was submitted to the NRC, it was thoroughly reviewed by EG&G Idaho, Inc., and the TTC/SNL on behalf of the DOE.

- The two Model 125-B casks were fabricated according to a quality assurance plan approved by the NRC. As an added measure of quality assurance, the DOE, through its contractor EG&G Idaho, Inc., provided an inspector in residence at the fabrication facility and additional quality overview during the entire construction process, witnessing by signature many key fabrication steps. After completion of fabrication, the NRC performed a 100 percent inspection of nondestructive examination records for both casks. That inspection probably was the most comprehensive audit of the quality records for design and fabrication of a cask ever performed by the NRC.

- At TMI, filling canisters with fuel, preparing canisters for loading into the Model 125-B cask, and loading seven canisters into each cask are responsibilities of GPU Nuclear, owner/operator of the TMI-2. Those responsibilities are discharged according to a quality assurance plan approved by the NRC and under the cognizance of NRC inspectors in residence at TMI. Each responsibility is broken down into a series of discrete tasks which are, in turn, defined and described in detailed operating procedures. Each procedure is approved by the NRC before use by GPU Nuclear. That level of quality assurance by both GPU Nuclear and NRC ensures that stipulations specified in the Certificate of Compliance issued by NRC for the Model 125-B cask and requirements from the DOE are met before a loaded rail cask is certified ready for transport from TMI to the INEL. But, in addition EG&G Idaho acting on behalf of the DOE, also provides an overview of canister loading and preparation for shipping operations including implementation of a DOE-approved canister acceptance program designed to ensure the canisters are properly prepared for shipment, long-term storage and use in the DOE's TMI-2 Core Examination R&D Program.

- At TMI, after seven canisters are loaded into the NuPac 125-B rail cask, containment components of the cask are closed and leak-tested sequentially to ensure that each level of the leak-tight containment provided by the cask functions as required. A leak-tight leak rate is only 10^{-7}atm-cm^3/s; i.e., a ping-pong ball quantity of gas or less would leak from the cask in 1 year. Once the cask is closed entirely and passed the leak tests, it is returned to its railcar, equipped with its overpacks, inspected for proper assembly and attachment to the railcar, surveyed radiologically, and certified ready for transport by GPU Nuclear. At this point, the cask is inspected again by an inspector of the NRC who conducts a radiological survey of the package and inspects accompanying documentation, ensuring that radiation levels around the cask meet limits specified by the Department of Transportation and NRC.

- Following the inspection by the NRC, another confirmation that everything is in order is performed by a representative of the DOE, before the DOE accepts title to the cask and contents. But, in addition, before the package leaves TMI, it is inspected by a representative of the Federal Railroad Administration, who reviews documentation and examines the railcar, cask, and attachments. Once that inspection is complete, the rail carrier inspects the package, the environmental cover is placed over the cask, and the cask is accepted for transport.

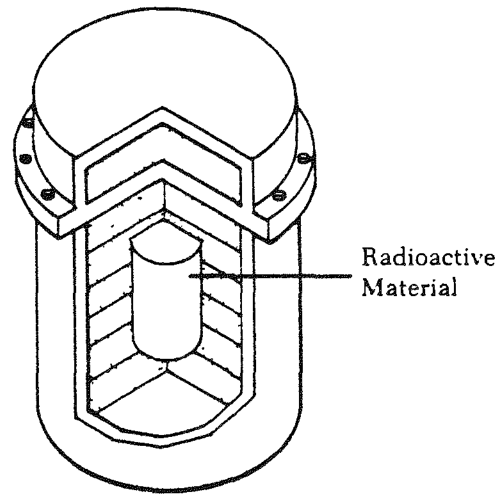
  It is worth noting that radiation levels at the surface of the first cask which left TMI in July were less than 2.5 mr/hr. That is much less than the 200 mr/hr at the surface permitted by the Department of Transportation. After transport of that cask from TMI to the INEL, representatives of the DOE monitored the cask and found no change in external levels of radiation.

- After the rail route between TMI and the INEL was selected, the Federal Railroad Administration inspected tracks of the entire route and issued an approval for use by the Model 125-B cask. In addition, Conrail performed a detailed examination of the tracks between TMI and the switchyard in East St. Louis, Illinois. Likewise Union Pacific Railroad performed a detailed examination of trackage between East St. Louis and the boundary of the INEL west of Idaho Falls, Idaho. The tracks are of the highest quality and under continuous surveillance by the carriers involved.

- The railcars used in these shipments are special eight-axle heavy-duty cars selected by DOE at extra cost to provide a wide margin of safety; the cars are rated for 165-ton loads, whereas the loaded cask nominally is 115 tons. A maintenance agreement was authorized by DOE with the Union Pacific Railroad to perform car inspection and maintenance every trip.

Radioactive materials are transported daily by land, air, and water. Many levels of safety are built into the shipments to ensure protection of the public and the environment. One level of protection is the packaging itself. Before shipment, all radioactive materials must be packaged in accordance with strict Federal requirements designed to prevent the release of any of the contents. Placards (brightly colored warning devices on the transport vehicles), marking, labels, and shipping papers all help to identify the radioactive nature of the cargo to handlers, emergency response personnel, and others who need to assure safety. Although precautions are taken in the transportation of these materials, accidents cannot always be avoided. Therefore, emergency response plans are in place to respond to any transportation accident that involves radioactive materials.

State and local government officials have the responsibility for initial emergency response to any accident involving hazardous materials, including those involving radioactive materials. The Federal Government provides guidance for State and local responders. The plans include information on such topics as: the assignment of responsibility; notification methods and procedures; provision of emergency equipment, facilities, and resources; prompt communication among principal response organizations and emergency personnel; and methods for providing accurate, timely information to the public.



The packaging for radioactive material is designed to retain its integrity under accident conditions.

DOE offers emergency response training courses to State and local personnel on the transportation of hazardous materials.

Training

Extensive training is available for drivers, shippers, fire fighters, police officers, medical personnel, and other individuals who have responsibility for responding to transportation accidents. The training is intended to prepare them for any accident involving radioactive materials. Drivers of vehicles transporting radioactive materials receive special training. The U.S. Department of Energy (DOE) requires a training program for contractor employees who are responsible for shipments of radioactive materials. DOE also offers, on a regional basis, a training course to State and local personnel on hazardous materials identification, transportation regulations, and emergency response principles.

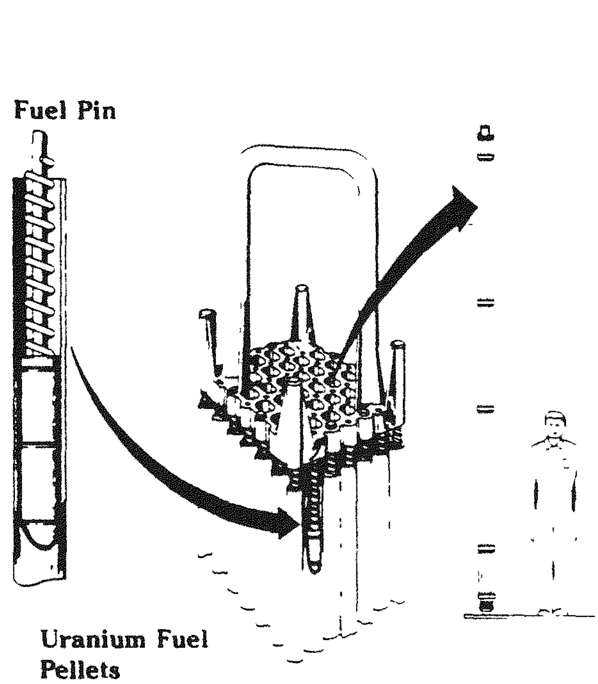
Introduction

American industries have been making, using, and transporting radioactive materials and wastes for more than 40 years. The nuclear-fueled powerplants that operate in this country are the second largest source of our electrical energy. They also require nuclear materials transportation. A major transportation need of these powerplants is to move high-level radioactive wastes, safely, primarily in the form of used or "spent" fuel, to a permanent disposal site. The U.S. Congress passed the Nuclear Waste Policy Act in 1982 calling for completion of the first permanent disposal site (repository) by 1998.

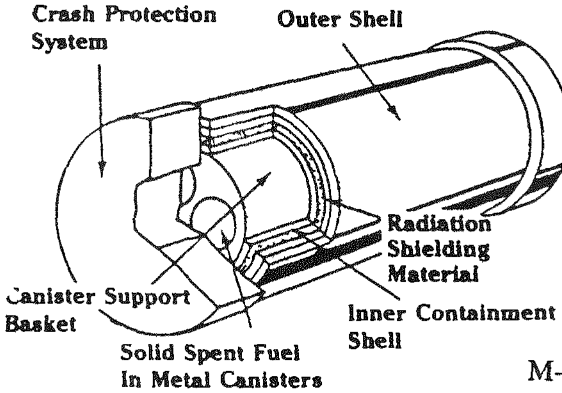
What is Spent Fuel?

The fuel for a nuclear powerplant is a specific form of the element uranium that, when prepared for use, is in the form of cylindrical ceramic pellets known as "fuel pellets." Each pellet is approximately ½ inch in diameter and 1 inch long. The fuel pellets are stacked in 12-foot-long hollow metal rods called "fuel pins." The fuel pins are grouped into "fuel assemblies" and placed into the core of a nuclear reactor. There, they are utilized to produce heat, which in turn is used to create steam to turn a turbogenerator to produce electricity.

After the usable energy has been expended, the highly radioactive spent fuel assemblies must be removed from the reactor and dealt with in a safe and environmentally acceptable manner. Presently, most spent fuel assemblies are stored at the powerplant in special pools filled with water where they cool. The spent fuel can be stored in this way for long periods of time;. however, pool storage was meant as a temporary measure and will continue only until a permanent radioactive waste disposal method is implemented.



Spent Fuel Shipping Cask



How Is Spent Fuel Transportation Accomplished?

The Containers

Spent fuel is packed into specially designed shipping casks and transported via truck, train, or barge. These casks are constructed primarily of steel with shielding material to help absorb radiation. The 25- to 100-ton containers are certified by the Federal Government to ensure that, in the event of a transportation accident, harmful levels of radiation would not be released.

bcc: (w/o Encl.)
A. A. Anselmo
L. J. Ball
W. A. Franz
P. J. Grant
R. C. Miller
H. W. Reno
R. C. Schmitt
M. J. Tyacke
D. L. Uhl
J. M. Wilson
Central Files

INEL
Idaho National Engineering Laboratory

January 8, 1987

Frederick A. Brunner, Ph.D., P.E.
Director
Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102

REQUEST FOR INFORMATION ON TMI-2 FUEL SHIPPING PROGRAM - TAS-1-87

Ref: F. A. Brunner ltr to T. A. Smith, Request for Information, Dec. 13, 1986

Dear Dr. Brunner:

Thank you for your interest in the Three Mile Island Unit 2 (TMI-2) fuel shipping program. Your assistance in disseminating factual information on the program is greatly appreciated. In the referenced letter you requested documents relating to criticality, zirconium pyrophoricity, hydrogen and oxygen control, and steam generation. I have enclosed the following documents which I hope will satisfy your request:

--Technical Evaluation Report for Defueling Canisters, (TER 15737-2-G03-114, Rev. 1) which discusses fuel canisters in detail including criticality and hydrogen/oxygen generation evaluations.

--Criticality Evaluation (Section 6 of the NuPac 125-B Cask Safety Analysis Report).

--NRC Staff Safety Evaluation of Defueling Canister Design, which contains Nuclear Regulatory Commission findings and conclusions on the adequacy of the canisters in several areas including criticality.

--TMI-2 Pyrophoricity Studies (GEND 043).

--Hydrogen Control in the Handling, Shipping, and Storage of Wet Radioactive Waste (GEND 052).

--Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris, (GEND 051) which discusses pyrophoricity, steam generation, and hydrogen/oxygen controls.

EG&G Idaho Inc P.O. Box 1625 Idaho Falls, ID 83415

Also, per my December 23, 1986 telephone conversation with Mr. Ron Kucera, of your office, I have enclosed copies of the following letters to Mrs. Leo Drey, of University City, Missouri:

--TAS-5-86, May 1, 1986

--TAS-11-86, July 28, 1986

--TAS-12-86, August 12, 1986

--TAS-18-86, September 5, 1986

--TAS-22-86, November 7, 1986

--TAS-24-86, November 26, 1986

Please contact me if I might be of further assistance.

Very truly yours

Terry A. Smith
Public Information Office

ka

Enclosures:
As Stated

cc: (w/o Encl.)
P. D. Grimm, DOE-DP
D. J. McGoff, DOE-NE
P. Mygatt, DOE-ID
C. R. Robertson, DOE-ID
J. Threlkeld, DOE-CP
W. R. Young, DOE-TMI
J. O. Zane, EG&G Idaho

John Ashcroft
Governor

STATE OF MISSOURI

DEPARTMENT OF PUBLIC SAFETY
OFFICE OF THE ADJUTANT GENERAL

EMERGENCY MANAGEMENT AGENCY

P. O. Box 116
Jefferson City, Missouri 65102
Phone 314 751-9500

Richard D. Ross
Director

January 21, 1987

Terry A. Smith
Public Information Office
EG & G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415

Dear Terry:

Ron Kucera, Missouri Department of Natural Resources, has told me of your running correspondence with Kay (Mrs. Leo) Drey regarding TMI 2 shipping information.

The documents you sent to DNR contain information I sincerely wish we had had at the outset. We could have been more prepared for some of the questions. Please send us copies of the following documents:

1. Technical Evaluation Report for Defueling Canisters; TER 15737-2-G03-114, REV 1

2. Criticality Evaluation (Section 6 of NuPac 125-B CSAR.)

3. NRC Staff Safety Evaluation of Defueling Canister Design.

4. TMI-2 Pyrophoricity Studies (GEND 043)

5. Hydrogen Control in the Handling, Shipping, and Storage of Wet Radioactive Waste (GEND 052)

6. Evaluation of Special Safety Issues Associated with Handling the Three Mile Island Unit 2 Core Debris, (GEND 051)

It is unfortunate that, while we were at TMI last June, nobody suggested we take some extra time to look into these particular isues in more depth.

Direct the requested docuemnts to:

Wm. K. Johnson, Chief
Technological Hazards Branch
SEMA
P.O. Box 116
Jefferson City, Mo 65102

Thank you for your prompt attention.

Sincerely,

R. D. Ross
Director

WKJ:sb

Mrs. Leo Drey
515 West Point Avenue
University City, MO 63130

March 19, 1987

Mr. Charles E. MacDonald, Chief
Transportation Certification Branch
Division of Fuel Cycle and Material Safety
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. MacDonald:

I would appreciate your response to the following questions relating to the Three Mile Island-2 fuel debris canisters. I cannot find this information in the NRC's Public Document Room documents to which you referred me in your letter of November 6, 1986, or in documents provided by the Department of Energy in February 1987 in response to a Freedom of Information Act request filed by the Missouri Coalition for the Environment.

1. My first question has to do with the pyrophoricity of the zirconium metal alloy which originally made up the 40,000 fuel rod tubes (which in turn contained the uranium fuel pellets). As has been recognized since April 1979, this Zircaloy tubing melted during the earliest stages of the TMI-2 accident. (The fact that the uranium fuel itself had also melted was only officially confirmed and announced on February 21, 1985.)

   The difficulties encountered in extricating the melted, but re-hardened uranium fuel, Zircaloy tubing, and non-fuel parts (e.g., the fuel assembly end-fittings) have apparently forced workers to continue experimenting with a wide range of chipping, hammering, digging, and drilling tools. The variety of removal techniques attempted has produced unpredictable debris particle sizes and shapes, unpredictable levels of radioactive concentrations, and unpredictable collections of radioactive isotopes -- as well as a range of spacings within and between any given hodge-podge of these fragments.

   It is my understanding that whereas the recombiner catalyst cannot function if submerged in water, moistened fine zirconium particles, on the other hand, can be both pyrophoric and explosive if not submerged. That is, finely divided zirconium must be kept either virtually dry (with moisture content below 3 percent by weight, a condition highly unlikely within a TMI canister) or completely submerged if an explosion or spontaneous ignition is to be prevented. (Please see the Rockwell International report on zirconium pyrophoricity published in November 1984, p. 19; and their report on special TMI-2 core debris handling problems, June 1985, passim.)

   Question #1. Upon which of these conflicting regimes -- submerged or not -- are you relying? (This was one of the many questions I had asked you in my letter of October 9, 1986.)

2. My next set of questions has to do with the recombiner catalyst: As I understand the recombiner catalyst technology, in order to try to prevent

a flammable gas mixture or an internal pressure buildup within the canister -- in other words, in order to try to keep a fire or hydrogen explosion from occurring -- a recombiner catalyst bed is installed at the top and bottom of each canister. I had understood the catalysts are present to reunite the radiolytically-generated hydrogen and oxygen gases (released from the residual water entrapped within the fuel debris) back into water and thereby prevent the formation of combustible gas mixtures.

I have now read that gases may also be generated from the following additional sources:

a. the radiolytic decomposition of the borated aluminum sheets or boron carbide pellets which are added to the canisters to prevent an uncontrolled chain reaction (NuPac: Cask SAR; Rev. 2, p. 6-12-b);

b. the radiolytic decomposition of the concrete within the fuel canister shell cavity, designed to keep the Boral sheets in place. (A similar radiolytic process is described in the B&W Canister Final Design Technical Report; Rev. 5, p. 9); and

c. the reaction of finely divided zirconium with the residual water (and, if present, of the even more reactive zirconium hydrides).

d. In addition, I wonder about the radioactive hydrogen (tritium) created as a ternary fission product within the fuel and about other gaseous fission products leaching out into the canister void during transit and storage, adding to the pressure buildup.

I have become all the more concerned about the amount of recombiner catalyst present in any given canister because of a letter dated December 12, 1986, from William Travers (Director, NRC's TMI-2 Cleanup Project) to Frank Standerfer (Vice President/Director, TMI-2, GPU Nuclear). In his letter Dr. Travers responds to a November 10, 1986, letter from GPU Nuclear which had apparently reported that some of the catalytic recombiner beds had not been installed symmetrically or within specified tolerances. The canister design provides for half the catalyst to be installed at one end of the canister, and half at the other -- to make certain that a sufficient amount is kept unsubmerged and thus available for recombining, no matter in what position the canister may be (for instance, following a derailment). However, because of faulty installation, only half of the remaining unsubmerged catalyst -- one fourth of the total amount -- is now available for recombining the gases. Dr. Travers also mentions unresolved problems with "canister dewatering and minimum void volume."

Question #2. Did the NRC staff perform corroborating calculations to determine if the Babcock & Wilcox designs for the canisters call for an amount of recombiner catalyst adequate to convert the total amount of all those gases to non-combustible compounds?

Question #3. Can the recombining catalyst become deactivated or fatigued or coated over as a result of interaction over time with the gases generated within the canister, and thereby be rendered non-functional?

Question #4. What monitoring is being done of the canister to determine if there is any buildup of gases/pressure or rapid increase of temperature due to reactions taking place inside the canister -- both during transit and during the canister's 30-year storage in the Idaho water pit?

3. My final question (for this letter) has to do with information provided in a February 13, 1987, GPU Nuclear news release. The executive vice president said that his company "would lease a third rail cask to supplement two DOE casks now being used to ship debris from TMI. Availability of a third cask is expected to help assure meeting a goal of completing debris shipments by the projected end of the Cleanup Program in 1988."

Question #5. If it is correct that GPUN is leasing a cask, would you please describe that cask briefly and send me a copy of its NRC certificate of compliance?

Your response will be appreciated.

Sincerely,

Kay Drey

p.s. If you would prefer that these questions be submitted to the Nuclear Regulatory Commission as a request under the Freedom of Information Act, please let me know.

JUN 22 1987

Dear Mrs. Drey:

Please forgive my delay in responding to your letter of March 19, 1987 concerning questions on pyrophoricty and combustible gases for the core debris from Three Mile Island-2. As indicated in our conversation of April 24, the Freedom of Information Act is not appropriate for such requests, but we have prepared a specific response to your questions.

Basically, laboratory tests and measurements of TMI-2 core debris indicate that there is little potential for the existance of pyrophoric conditions in the TMI-2 core debris. In addition, tests and measurements for hydrogen gas accumulation rates for canisters containing TMI-2 core debris show that it would take several years on average to reach concentrations where hydrogen build-up would be of concern.

It should be noted that tests and measurements are required prior to each shipment of TMI-2 core debris to identify conditions that may have potential adverse effects on public health and safety. Enclosed is a response to the questions in your letter of March 19, 1987. We trust that this information will be helpful.

Original Signed by
CHARLES E. MACDONALD

Charles E. MacDonald
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Enclosure:
As stated

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JUN 2 2 1987

Enclosure to ltr dtd: ______________

Question 1#. Upon which of these conflicting regimes -- submerged or not [dry or completely submerged fine zirconium particles] -- are you relying?

ANSWER:

Neither submergence nor complete drying of the fuel debris is relied upon to preclude a pyrophoric event during transportation of the TMI-2 fuel debris. The determination that the fuel debris does not present a significant potential for a pyrophoric event during transport and storage is based on a number of considerations. The existence of potentially pyrophoric zirconium and zirconium hydride in TMI-2 core debris cannot be completely ruled out. However, laboratory tests and studies for TMI-2 core debris have shown that, it is extremely unlikely for conditions to exist that could initiate or sustain a pyrophoric event. In order for a metallic material to undergo a pyrophoric reaction the following conditions must be present:

- The material must be in a chemical form or state that can undergo oxidation.
- The material must have a large surface to volume ratio with particle diameters of less than 50 microns.
- The material must be of a sufficient concentration to initiate, sustain, and propagate the ignition.
- The material must be exposed to an oxidizing environment where the heat generation is much greater than the heat loss rate.

Laboratory tests of TMI-2 core debris samples were performed prior to removal of the reactor plenum and commencement of defueling. In these tests rigorous attempts were made to ignite the samples. Samples were also mechanically agitated in an attempt to disturb the protective oxide film on the zircalloy to expose a fresh unoxidized surface. All tests failed to produce a pyrophoric reaction. These tests concluded that the loose core rubble presented little potential for the existence of pyrophoric conditions. Aggressive defueling techniques such as drilling, cutting, or sawing could expose fresh zirconium surfaces leading to conditions that might support a pyrophoric reaction; therefore, the issue was studied further.

For the aggressive defueling techniques, it is believed that freshly exposed unoxidized zirconium surfaces will quickly oxidize. This will result in a protective oxide layer over any newly exposed surfaces. This is because of the high dissolved oxygen content and pH of the reactor coolant. Further dilution of the fresh material with non-pyrophoric material will prevent sufficient heat build up to cause ignition.

The conclusion of several studies was that 1) there is little potential for the existence of pyrophoric material in the TMI-2 core debris, 2) as fresh surfaces are exposed during defueling they will probably oxidize in the reactor coolant system before being exposed the to atmosphere, 3) if potentially pyrophoric surfaces are exposed and do not oxidize, they will probably be in the form of course turnings, chips, or shavings which do not present significant pyrophoric potential, 4) the material will be significantly diluted with inert non-pyrophoric material, 5) because the mass of material present provides a heat sink, there is very little potential for the material to react and retain sufficient heat to cause an ignition, 6) the fuel debris is shipped in an inert gas environment that will not support a pyrophoric reaction, and 7) even under hypothetical accident conditions during transportation, the maximum temperatures seen by the fuel debris is not sufficient to cause ignition of the diluted potentially pyrophoric material.

Thus, it was determined that the potential for the pyrophoric event during shipment of the TMI-2 core debris is insignificant.

QUESTION #2. Did the NRC staff perform corroborating calculations to determine if the Babcock & Wilcox designs for the canisters call for an amount of recombiner catalyst adequate to convert the total amount of all those gases to non-combustible compounds?

ANSWER:

The gas calculations provided by the applicant to demonstrate design adequacy of the Model No. 125-B are conservative upper bound estimates to establish design parameters. The calculations (design analysis) have been reviewed by the NRC staff and found to be acceptable. In addition, the staff specified Condition No. 8 in Certificate of Compliance No. 9200 which must be met for each cask shipment. The condition places a limit on gas build-up, and requires a demonstration of compliance for each package before each shipment. Indications are that years would be required for combustible mixtures to develop in the canisters. The amount of the recombiner catalyst is not essential because of the low gas generation rates which have been found by tests and measurements done prior to each shipment.

QUESTION # 3. Can the recombining catalyst become deactivated or fatigued or coated over as a result of interaction over time with the gases generated within the canister, and thereby be rendered non-functional?

ANSWER:

Catalysts do not become significantly deactivated or fatigued in their role of passively controlling hydrogen generation. Only water has been found to have a significant effect on reducing catalyst performance in the canisters. Catalysts which are wetted become temporarily ineffective, but exhibit rapid recovery upon drying. The effectiveness of the catalyst is based in part on tests and measurements required prior to each shipment. Other factors include a mix of catalysts that are effective under various conditions.

QUESTION #4. What monitoring is being done of the canister to determine if there is any build-up of gases/pressure or rapid increase in temperature due to reactions taking place inside the canister -- both during transit and during the canister's 30-year storage in the Idaho water pit?

ANSWER:

Determinations must be made prior to each shipment that build-up of combustible mixtures will not develop during the course of transport. No measurements are made during actual transport. A sampling procedure has been instituted at Idaho to verify gas generation estimates. Sampling is done upon receipt and during storage.

QUESTION #5. If it is correct that GPUN Is leasing a cask [discussed in GPU Nuclear news release February 13, 1987], would you please describe that cask briefly and send me a copy of its NRC certificate of compliance?

ANSWER:

We do not have information on the specific cask or of GPUN's leasing of a cask referred to in the February 13, 1987 GPU Nuclear news release.

JACK BUECHNER
2D DISTRICT, MISSOURI

Congress of the United States
House of Representatives
Washington, DC 20515

March 26, 1987

The Honorable John Herrington
Secretary of Energy
Department of Energy
1000 Independence Avenue, S.E.
Washington, D.C. 20585

Dear Mr. Secretary:

I am writing to ask you to help resolve a problem which is of great concern and potential danger to many residents of the St. Louis metropolitan area. As you know, on March 24, 1987 a train carrying radioactive waste from Three Mile Island collided with a car in the St. Louis area. Fortunately, a major disaster was averted. But will we always be so fortunate? What will happen next time if the train is traveling at a faster speed?

For several months shipments of high-level radioactive waste from Three Mile Island have been transported through St. Louis to Idaho Falls, Idaho. This has caused significant alarm among the citizens of my home district. Several letters from concerned residents have been written inquiring about the necessity of shipping this waste through highly populated areas. On January 7th, Congressmen William Clay and Richard Gephardt sent a letter to you calling upon the Department of Energy to comply with federal law by preparing a supplemental Environmental Impact Statement on this shipping project. Still the shipments continue, while serious safety and health issues remain unaddressed.

At a recent hearing of the Committee on Science, Space, and Technology on March 17, 1987, a representative of the Department of Energy mentioned that only a portion of the waste transported to the Idaho facility was to be tested. Why, then, if only a portion of the waste is to be tested are we transporting all the waste? In addition, once the testing is completed, where will the waste go for permanent storage?

Mr. Secretary, in light of the many unanswered questions concerning the shipment of the radioactive waste, I urge you to immediately stop the shipments. At the very least, an alternative route through less populated areas seems prudent.

Questions have been raised about the safety of the transportation of the waste. Unfortunately, my predecessor did not give me his files on this subject so mine are incomplete in regards to any statements or decisions you may have made in response to these inquiries. Please forward any of these statements to my office at your earliest convenience.

I thank you for examining these concerns and I look forward to hearing from you regarding your views.

With best wishes I am,

Sincerely,

Jack Buechner

Jack Buechner
Member of Congress

APR 2 9 1987

Honorable Jack Buechner
House of Representatives
Washington, DC 20515

Dear Mr. Buechner:

Thank you for your letter of March 26, 1987, to Secretary of Energy John S. Herrington regarding shipments of spent nuclear fuel from the Three-Mile Island (TMI) facility. As the head of the organization in the Department of Energy (DOE) responsible for transportation of those radioactive materials, your letter was sent to me for a reply.

Enclosed are copies of the letters and responses to Congressmen Young, Clay, and Gephardt you requested on issues raised by the TMI-2 shipping program. Additionally, I have enclosed a fact sheet which responds to your questions concerning environmental documentation, fuel analysis, and transportation systems decisions. We hope these documents will assist you in responding to your constituents.

The primary protection of the health and safety of the public is provided by the shipping cask. It is an extremely rugged steel and lead container designed to withstand transportation accidents including impacts, punctures, fires, and water immersions more severe than normally seen in transportation accidents. The TMI-2 casks were placed in use only after careful review by the Nuclear Regulatory Commission (NRC). These same standards codified in Federal regulations have resulted in an exemplary safety record for radioactive materials unparalleled by any other hazardous material.

We believe the current TMI-2 route provides a very high degree of safety for the shipments and the public. DOE and rail carriers jointly selected a route having the highest quality track while minimizing time in transit. Direct routes avoid diversions and excessive switching delays and generally result in use of the highest track rating. As an added safety measure, we asked the Federal Railroad Administration to inspect the entire route to assure its safety. Routine inspections of the cask and railcar are conducted at the origin site by the Department of Transportation, Federal Railroad Administration, NRC, DOE, and the rail carriers. Similar inspections en route are performed by various States, including the State of Missouri. Finally, a designated individual trained in emergency response travels with each shipment.

Our plans are to continue to remove the entire core debris from the TMI-2 reactor for examination and testing at our Idaho facility. We will not know the precise sections of the core to be looked at until it is completely removed. More importantly, we want to make sure TMI does not become a long-term waste disposal site.

We understand the concerns the public has about these shipments and share a mutual goal of providing for the safety of the public and protection of the environment. Please be assured we use extreme care in our transportation activities.

I hope this information will be helpful to you. I appreciate the opportunity to respond to your inquiry.

Sincerely,

ORIGINAL SIGNED BY
S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

2 Enclosures

Distribution:
so: Addressee
4bcc: ES (ES87-003679/Due: 4-13-87) w/orig. incmg & ticket
1bcc: CP-30 w/copy ticket & incmg
1bcc: CP-1
2bcc: DP/MR
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2bcc: DP-12
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1bcc: Originator
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1bcc: DP-10 Suspense
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1bcc: NE-1
1bcc: GC-31
1bcc: RW-33

DP-121:PGrimm:ebm:353-3506:4-13-87:WANG 25336 (file: 5822.6)

Correspondence Reviewer: G. Payne
DP Control Number: DP-87-000266

EH-1	NE-1	GC-31
See attached		
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DATE 4- -87
RTG SYMBOL DP-121
INITIALS/SIG LHarmon
DATE 4- -87
RTG SYMBOL DP-12
INITIALS/SIG THindman
DATE 4-15-87
RTG SYMBOL DP-12
INITIALS/SIG DLytle
DATE 4-16-87
RTG SYMBOL DP-10
INITIALS/SIG JMeinhardt
DATE 4-17-87
RTG SYMBOL DP-2
INITIALS/SIG
DATE 4-21-87
RTG SYMBOL DP-2
INITIALS/SIG DuBe
DATE 4-21-87
RTG SYMBOL CP-30
INITIALS/SIG
DATE 4-20-87

CP40
Re attached
4/29/87

M-90

DOE F 1325.10

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Department of Energy
Washington, DC 20585

RECEIVED

March 11, 1987

Honorable William L. Clay
House of Representatives
Washington, DC 20515

Dear Mr. Clay:

Thank you for your letter of January 7, 1987, to Secretary of Energy John S. Herrington, regarding the shipment of spent fuel from the Three Mile Island (TMI) reactor in Pennsylvania to the Department of Energy (DOE) Idaho National Engineering Laboratory near Idaho Falls. In your letter, you raised some questions regarding the environmental review of this activity. As the DOE organization responsible for oversight of compliance with the National Environmental Policy Act (NEPA), your letter has been forwarded to my office for reply. An interim response was provided to you by the Department's Office of Defense Programs on January 27, 1987.

In response to your concerns regarding the Department's compliance with NEPA, let me explain that DOE considered the environmental impacts of the TMI fuel shipments in accordance with the established procedures of the Council on Environmental Quality NEPA regulations (40 CFR 1500-1508) and the Department's published guidelines for compliance with NEPA (45 FR 20694), as amended. DOE determined that the TMI shipments fall within a categorical exclusion in DOE's NEPA guidelines, namely, "Actions which are substantially the same as other actions for which the environmental effects have already been assessed in a NEPA document, and have been determined by DOE to be environmentally insignificant and where such assessment is currently valid." Therefore, neither an environmental assessment nor an environmental impact statement (EIS) is required for the TMI shipments.

In reaching this conclusion, DOE considered previous NEPA analyses for irradiated fuel shipments routinely transported by the DOE by various transportation modes as well as the analysis of the environmental effects of shipments of much larger quantities of spent nuclear fuel developed in the Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes (NUREG-0170), which was prepared by the Nuclear Regulatory Commission (NRC). In addition, a specific EIS was issued by NRC related to the programmatic effects of handling the TMI spent fuel, Final Programmatic Environmental Impact Statement Related to Decontamination and Decommissioning of Radioactive Wastes Resulting from March 28, 1979 Accident: Three Mile Island Nuclear Station, Unit 2 (NUREG-0683.)

Based on our review, it is the Department's judgment that these NEPA analyses support the above-cited categorical exclusion and that there is no new information that refutes the basic finding that the TMI-2 shipments are environmentally insignificant. Consequently, a supplement to NUREG-0683 is not required.

With respect to your concerns regarding the relative risks associated with truck and rail transportation, it should be noted that NUREG-0683 specifically addressed the impacts on workers and the public related to the transportation of the TMI fuel by rail in Appendix U. In general, the cumulative impacts of rail transport are shown to be less than truck transport, which are insignificant. In fact, NUREG-0683 noted that rail transport may be preferable in some cases, e.g., when shielding requirements "for irradiated fuel canisters necessitate the use of large, heavy casks and when off-loading rail spurs are available near the storage or disposal location" (page 9-17).

In summary, we believe, for the reasons outlined above, that the potential environmental impacts of these fuel shipments--by either rail or truck transport-- have been adequately considered in existing NEPA documents which are still valid, and that the impacts are clearly insignificant. Therefore, the preparation of an EIS supplement is not necessary. We have conducted six successful shipments to date. I can assure you that the Department will continue to conduct these activities in a safe and environmentally sound manner.

If you have any further questions on this matter, please do not hesitate to contact us.

Yours truly,

Mary L. Walker
Assistant Secretary
Environment, Safety and Health

APR 1 3 1987

DP-121

Honorable Arlen Specter
United States Senate
Washington, DC 20510

Dear Senator Specter:

Thank you for your letter dated March 5, 1987, concerning the shipment of the damaged Three-Mile Island reactor core. As head of the Department of Energy organization responsible for transportation of radioactive materials, your letter was sent to me for a reply.

We understand the concerns expressed by Debra Wilson in her letter to you. Please be assured we share a mutual concern about protecting public health and safety and the environment.

The letter to you also included a press release and a letter from Congressmen Clay and Gephardt calling for a supplemental environmental impact statement. The Department has very carefully reviewed the Congressmen's request. Our reply is enclosed. We believe the environmental impacts are clearly insignificant and the existing statements are adequate.

I want to reassure you safety remains paramount in all our decisions on transporting nuclear materials.

Sincerely,

original signed by D. Ofte

for S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

Enclosure

Distribution:
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4bcc: ES (ES87-002640/Due: 3-31-87) w/orig. incmg & ticket
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1bcc: NE-1 4/ /87
1bcc: EH-1

DP-121:LHarmon:ebm:353-3506:3-23-87:WANG 2500o (file: 5822.6)

Correspondence Reviewer: G. Payne
DP Control Number: DP-87-000187

CONCURRENCES	
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DATE	3-26-87
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DATE	3-2 -87
RTG SYMBOL	DP-10
INITIALS/SIG	JMeinhardt
DATE	3-31-87
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RTG SYMBOL	EH-1
INITIALS/SIG	attchd
DATE	3- -87

M-93

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DOE F 1325.10
(7-79)

Department of Energy
Washington, DC 20585

March 11, 1987

Honorable Richard A. Gephardt
House of Representatives
Washington, DC 20515

Dear Mr. Gephardt:

Thank you for your letter of January 7, 1987, to Secretary of Energy John S. Herrington, regarding the shipment of spent fuel from the Three Mile Island (TMI) reactor in Pennsylvania to the Department of Energy (DOE) Idaho National Engineering Laboratory near Idaho Falls. In your letter, you raised some questions regarding the environmental review of this activity. As the DOE organization responsible for oversight of compliance with the National Environmental Policy Act (NEPA), your letter has been forwarded to my office for reply. An interim response was provided to you by the Department's Office of Defense Programs on January 27, 1987.

In response to your concerns regarding the Department's compliance with NEPA, let me explain that DOE considered the environmental impacts of the TMI fuel shipments in accordance with the established procedures of the Council on Environmental Quality NEPA regulations (40 CFR 1500-1508) and the Department's published guidelines for compliance with NEPA (45 FR 20694), as amended. DOE determined that the TMI shipments fall within a categorical exclusion in DOE's NEPA guidelines, namely, "Actions which are substantially the same as other actions for which the environmental effects have already been assessed in a NEPA document, and have been determined by DOE to be environmentally insignificant and where such assessment is currently valid." Therefore, neither an environmental assessment nor an environmental impact statement (EIS) is required for the TMI shipments.

In reaching this conclusion, DOE considered previous NEPA analyses for irradiated fuel shipments routinely transported by the DOE by various transportation modes as well as the analysis of the environmental effects of shipments of much larger quantities of spent nuclear fuel developed in the Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes (NUREG-0170), which was prepared by the Nuclear Regulatory Commission (NRC). In addition, a specific EIS was issued by NRC related to the programmatic effects of handling the TMI spent fuel, Final Programmatic Environmental Impact Statement Related to Decontamination and Decommissioning of Radioactive Wastes Resulting from March 28, 1979 Accident: Three Mile Island Nuclear Station, Unit 2 (NUREG-0683.)

Based on our review, it is the Department's judgment that these NEPA analyses support the above-cited categorical exclusion and that there is no new information that refutes the basic finding that the TMI-2 shipments are environmentally insignificant. Consequently, a supplement to NUREG-0683 is not required.

With respect to your concerns regarding the relative risks associated with truck and rail transportation, it should be noted that NUREG-0683 specifically addressed the impacts on workers and the public related to the transportation of the TMI fuel by rail in Appendix U. In general, the cumulative impacts of rail transport are shown to be less than truck transport, which are insignificant. In fact, NUREG-0683 noted that rail transport may be preferable in some cases, e.g., when shielding requirements "for irradiated fuel canisters necessitate the use of large, heavy casks and when off-loading rail spurs are available near the storage or disposal location" (page 9-17).

In summary, we believe, for the reasons outlined above, that the potential environmental impacts of these fuel shipments--by either rail or truck transport-- have been adequately considered in existing NEPA documents which are still valid, and that the impacts are clearly insignificant. Therefore, the preparation of an EIS supplement is not necessary. We have conducted six successful shipments to date. I can assure you that the Department will continue to conduct these activities in a safe and environmentally sound manner.

If you have any further questions on this matter, please do not hesitate to contact us.

Yours truly,

Mary L. Walker
Assistant Secretary
Environment, Safety and Health

APR 27 1987

Honorable John C. Danforth
United States Senate
Washington, DC 20510-6125

Dear Senator Danforth:

Thank you for your letter of March 4, 1987, to Secretary of Energy John S. Herrington regarding the concerns raised by Council Member Phyllis L. Evans of the City of Kirkwood on shipping radioactive materials by train. I have been asked to reply because my office is the Department of Energy (DOE) organization responsible for the transportation of those radioactive materials.

We understand the concerns mixed rail shipments may seem to present. However, the extraordinary safety precautions taken with spent fuel shipments more than address rail transport concerns. Those precautions first and foremost require, by regulation, the shipping cask contain the radioactive materials even in a severe shipping accident. This is the basis from which all Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) radioactive materials transportation regulations assure public health and safety and the protection of the environment. The placement and configuration of railcars is only a minor factor in addressing safety on spent fuel shipments.

The Three-Mile Island (TMI) fuel debris is securely protected by the Model 125-B shipping cask. There are three independent levels of protection that must be breached before a release of fuel material from the cask could occur. There are separate inner and outer containers and special fuel debris canisters. The internal canisters which hold the debris are dewatered to a drip-dry condition by gas displacement before shipment. Only a small amount of residual water remains. Extensive thermal analysis has shown it is extremely improbable that steam could be generated under any circumstances. Furthermore, if such an improbable event did occur, rupture discs on the shipping casks would open to release pressure precluding the possibility of the cask bursting. The Model 125-B cask was certified by the NRC only after assuming the cask is engulfed in a fire much more severe than is normally experienced in railroad accidents.

DOT regulations restrict the positioning of railcars carrying radioactive materials (49 CFR 174.89). This requirement further precludes the remote possibility of interaction among hazardous materials in the same train. However, even in a severe transportation accident involving other cargoes, a spent fuel shipping cask would essentially be unaffected by accident circumstances including crushing, puncturing, thermal, or water immersion scenarios.

The DOE currently ships radioactive materials both by exclusive-use and normal train service. There are no plans to change this policy since there is no safety-related reason for doing so. TMI shipments are continuing in exclusive-use service. However, regular train service could be used if program needs change.

If we can provide further information on this matter, please let us know.

Sincerely,

/S/

S. R. Foley, Jr.
Assistant Secretary
for Defense Programs

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so: Addressee
4bcc: ES (ES87-002880/Due: ~~3-30-87~~ 4-21-87) w/orig. incmg & ticket
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2bcc: DP-12
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1bcc: Originator
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1bcc: DP-10 Suspense
1bcc: EH-1
1bcc: NE-1

DP-121:PGrimm:ebm:353-3506:4-13-87:WANG 2532o (file: 5822.6)

Correspondence Reviewer: G. Payne
DP Control Number: DP-87-000210

CONCURRENCES
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DATE 4-15-87
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DATE 4- -87
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INITIALS/SIG
DATE 4- -87

M/R:
File Code ________
Coordination
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DOE-Field yes ✓ no ___ name Phil Grant org. TMI
Other agency yes X no ___ name E. Pritchard - FRA, D. Hannen - DOT
Other yes ___ no ___ name ________ org. ________
Congressional Subject? yes ___ no ___
Policy Issue? yes ___ no ___
Budget Issue? yes ___ no ___
Comments:

DOE F 1325.10

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The Snake River Alliance

Box 1731 · Boise ID 83701 · 208/344-9161

Mr. Terry Smith
EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415

June 23, 1987

Dear Mr. Smith,

The continued shipment of debris from TMI-2 and the storage of this highly radioactive material on site at the Idaho National Engineering Laboratory poses unacceptable risks to communities across America. Such transfer of radioactive debris should cease immediately and resume only after a full Environmental Impact Statement has been prepared to the satisfaction of all.

In the meantime I would appreciate answers to the following questions.

1. How does EG&G monitor the build-up of oxygen and hydrogen gases within the storage canisters? It is my understanding that there is not a pressure disk or pressure relief valve on the cannisters. There are a number of circumstances that might lead to the failure of the recombiner catalyst causing generation of gas within the canister.

2. Have provisions been made to vent a build-up of hydrogen and oxygen gases from the cannisters? If so please provide details.

3. To my knowledge there has been no analysis done on the impact a ruptured canister would have on workers, nearby populations, and the environment (and other adjacent canisters). I would like to know what the impacts of such an unplanned incident would be. If such an analysis has been made I would appreciate a copy.

A prompt reply would be welcome.

Sincerely,

Liz Paul

Liz Paul

cc: P. Mygatt, DOE-ID
D. Ofte, DOE-ID
C. Andrus, Governor

M-99

A. A. Anselmo
A. L. Ayers
L. J. Ball
J. M. Broughton
W. B. Engel
W. A. Franz
P. J. Grant
K. M. Haddock
H. W. Reno
R. C. Schmitt
M. J. Tyacke
D. L. Uhl
J. M. Wilson
Central Files

INEL
Idaho National Engineering Laboratory

August 6, 1987

Ms. Liz Paul
The Snake River Alliance
Box 1731
Boise, ID 83701

REQUEST FOR INFORMATION ON TMI-2 FUEL SHIPMENTS AND INEL STORAGE - TAS-23-87

Ref: L. Paul ltr to T. A. Smith, request for information, June 23, 1987

Dear Ms. Paul:

Thank you for your letter concerning the Three Mile Island Unit 2 (TMI-2) fuel shipments and storage of the material at the Idaho National Engineering Laboratory (INEL). As I explained to you in previous correspondence, TAS-20-86 and TAS-24-86, the Department of Energy (DOE) is conducting the shipping program in full compliance with all applicable public law. Department of Transportation (DOT) guidelines are followed in all shipping procedures, and the Nuclear Regulatory Commission (NRC) has certified the shipping casks used for transporting the material. Previous congressional and regulatory actions and agreements between state and federal entities have made clean-up of the TMI-2 accident a national obligation, and the DOE is exercising its public responsibility in removing the damaged fuel and core materials from TMI and transporting them for safe storage at the INEL. Public safety has been the number one consideration in shipping cask design and transportation procedures.

I have enclosed a copy of a fact sheet entitled "Compliance with the National Environmental Policy Act (NEPA) of 1969 for TMI-2 Fuel Debris Shipments" which as the title suggests explains DOE compliance with NEPA for the shipping program.

Following are answers to your specific questions in the referenced letter:

Question 1. How does EG&G monitor the build-up of oxygen and hydrogen gases within the storage canisters? It is my understanding that there is not a pressure disk or pressure relief valve on the canisters. There are a number of circumstances that might lead to the failure of the recombiner catalyst causing generation of gas within the canisters.

Response 1. The canisters are not equipped with pressure relief valves because demonstrated gas generation rates and canister design preclude overpressurization during transport. We have a high degree of confidence in recombiner catalyst technology and cannot foresee a credible event in which the recombiner catalysts would

EG&G Idaho, Inc. P.O. Box 1625 Idaho Falls, ID 83415

fail to operate. Enclosed is a fact sheet entitled "Compliance with Nuclear Regulatory Commission (NRC) Requirements in the Certificate or Compliance (COC) No. 9200 for the Model 125-B Cask" which further explains monitoring and control of hydrogen and oxygen in the canisters.

Question 2. Have provisions been made to vent a build-up of hydrogen and oxygen gases from the canisters? If so please provide details.

Response 2. As explained in Response 1, we cannot foresee a creditable event that could lead to canister overpressurization during the short time the canisters are being transported. As an added safety measure, the shipping casks are equipped with rupture disks. Furthermore the canisters are vented continuously while in storage at the INEL.

Question 3. To my knowledge there has been no analysis done on the impact a ruptured canister would have on workers, nearby populations, and the environment (and other adjacent canisters). I would like to know what the impacts of such an unplanned incident would be. If such an analysis has been made I would appreciate a copy.

Response 3. Procedures are established that prevent workers and the public from ever coming in direct contact with loaded canisters. During transport, the canisters are confined in the shipping cask which provides two separate levels of containment. At the INEL canisters are unloaded remotely from the shipping casks inside the Test Area North Hot Shop, and during storage the canisters are under water in a storage pool that provides isolation.

Please don't hesitate to contact me if I can be of further assistance.

Very truly yours,

ORIGINAL SIGNED BY

Terry A. Smith
Public Information Office

ka

Enclosures:
As Stated (2)

cc: The Hon. C. D. Andrus, Governor-Idaho (w/o Encl.)
D. Giessing, DOE-NE
P. D. Grimm, DOE-DP
P. Mygatt, DOE-ID
F. L. Sims, DOE-ID
J. D. Threlkeld, DOE-CP
W. R. Young, DOE-ID
J. O. Zane, EG&G Idaho

VINCENT C. SCHOEMEHL, JR.
MAYOR

OFFICE OF THE DIRECTOR
DEPARTMENT OF PUBLIC SAFETY
401 CITY HALL
CITY OF SAINT LOUIS
MISSOURI 63103

ACTION
FRA

July 2, 1987

The Honorable Elizabeth Dole
Secretary
Department of Transportation
400 7th St. S.W.
Washington, D.C. 20590

Dear Mrs. Dole:

On June 23rd of this year at 9:30 a.m. the train carrying nuclear waste from Three Mile Island, Pennsylvania passed through the City of St. Louis, Missouri. While the City must accept these shipments, we decry the hour selected for this shipment. The daytime population in the City of St. Louis increases dramatically after 8:00 a.m. and the potential danger in a shipment of nuclear waste is such that as few people as possible should be exposed to the danger.

In the past, shipments have arrived in the early morning hours, which is less threatening to our citizens. We ask that you use the powers of your office to persuade the railroad companies involved (Conrail and Union Pacific) to schedule these shipments at a more reasonable time.

Thank you for your consideration and if further information is needed, please contact the Department of Public Safety in St. Louis.

Sincerely,

Gay Carraway
Director of Public Safety

GC/af

cc: Senator Bond
Senator Danforth
Congressman Buechner
Congressman Clay
Mayor Schoemehl

U.S. Department of Transportation
Federal Railroad Administration

Office of the Administrator

400 Seventh St., S.W.
Washington, D.C. 20590

Mr. Gay Carraway
Director of Public Safety
Office of the Director
Department of Public Safety
401 City Hall
Saint Louis, Missouri 63103

Dear Mr. Carraway:

I appreciate your letter concerning movement of the nuclear waste train from Three Mile Island, Pennsylvania.

The Department of Transportation (DOT) has placed a very high priority on ensuring the safe transportation of all radioactive materials, including radioactive waste. The Research and Special Programs Administration (RSPA) and the Federal Railroad Administration have promulgated a comprehensive system of regulations encompassing package design, fabrication, labeling and marking, cargo segregation and separation, and other regulations that ensure the integrity of the packaging during transport. These regulations are directed toward minimizing the chance of radiation exposure, reducing the possibility of damage to the packaging during transport, and preventing the release of the radioactive materials should an accident occur. This ensures that the impact on public health and safety from the transport of radioactive materials is minimized.

Both government and the private sector have conducted extensive research to determine the integrity of shipping containers under the performance criteria specified in DOT, Nuclear Regulatory Commission (NRC), and international standards. As an example, Sandia National Laboratories, a Department of Energy contractor in Albuquerque, New Mexico, evaluated the response of radioactive materials packages to very severe accident conditions. That evaluation consisted of three separate phases: (1) mathematical analysis; (2) scale-model testing; and (3) full-scale tests. In selecting test scenarios, considerable effort was given to selecting situations that could be conceived as realistic and yet were extremely severe. The selected accident scenarios were: (1) crashes of a tractor-trailer carrying a spent nuclear fuel cask into a massive concrete barrier at 60 and 84 miles per hour; and (2) the high-speed (81 miles per hour) crash of a locomotive into a truck-mounted spent nuclear fuel cask at a simulated crossing, including subsequent exposure to a fire.

The test results showed that the fuel casks were not damaged in any manner that would render them incapable of safely containing radioactive materials. Sandia National Laboratories concluded from these tests that the current analytical and scale-modeling techniques can accurately predict vehicular and cask damage in extremely severe accident conditions. The full-scale test showed that spent fuel casks are rugged containers capable of surviving extremely severe accidents. Modern casks are designed and constructed to equally rigid requirements and can be expected to survive equally well.

Experience has shown that shipping packages for radioactive materials also perform well in accident situations. A recent report, reviewing radioactive materials transport accidents, has been published by McClure and Emerson. The report, "A Review of U.S. Accident/Incident Experience Involving the Transportation of Radioactive Material, 1971-1980," was based on hazardous materials incident reports from DOT files with additional information from files of the NRC. There were no reports of damage to packages carrying high-level radioactive materials resulting in release of materials or loss of shielding effectiveness. The report concluded that the most commonly encountered problems involve packages carrying low-level radioactive materials in transit via highway or mishandled during loading or unloading operations. These incidents have been of small consequence because of the limited amount of material allowed in this type of package.

The Department of Energy examines proposed routes before a nuclear waste shipment is scheduled. The FRA is advised of the selected route and it is our policy, before the first shipment and routinely thereafter, to inspect the entire route for compliance with Federal track and signal requirements. FRA conducts inspections along the route to ensure that train crews are complying with the operating rules. Each nuclear cask car is inspected at points of origin and destination by FRA's motive power and equipment inspectors to assure compliance with FRA's Safety Appliance and Freight Car Safety Standards. FRA and/or RSPA hazardous materials inspectors also insure compliance with the Department's placarding, billing, crew notification, and train placement requirements.

One thing we do not control, however, is the scheduling of the train movement. Scheduling of the Three Mile Island nuclear train is handled by the Department of Energy. I have forwarded your correspondence to Mr. John Meinhardt, Deputy Assistant Secretary - for Nuclear Materials, Department of Energy, DP-10, Washington, D.C. for his response on this issue.

The radioactive materials transportation safety record has been excellent. Nevertheless, the Department of Transportation continually evaluates safety programs to insure that our regulations and resources are focused on areas where they are most needed.

I appreciate the opportunity to give you an overview of our safety program. If I can be of further assistance, please let me know.

Yours very truly,

John H. Riley
Administrator

OFFICE OF THE DIRECTOR
DEPARTMENT OF PUBLIC SAFETY
401 CITY HALL
CITY OF ST. LOUIS
MISSOURI 63103

INCENT C. SCHOEMEHL, JR.
MAYOR

December 22, 1987

GAY CARRAWAY
DIRECTOR

Mr. Lawrence H. Harmon, Director
Transportation Management Division
Office of Defense Waste and Transportation Management
Defense Programs
Department of Energy
Washington, D.C. 20545

Dear Sir:

I perceive great unconcern for the safety of citizens of St. Louis each time your department allows trains carrying Three Mile Island radioactive waste to pass through St. Louis during the morning rush hours. Not only did the train traverse St. Louis at about 7:45 a.m. on 12-22-87, but for the first time and completely unannounced the train carried three casks of radioactive waste.

In the past, the train transported one or two casks. Now suddenly and surprisingly, there are three casks passing through heavily populated areas of the City during the morning rush hours! It would appear that the danger to our citizens has increased exponentially by the arbitrary addition of more casks to these shipments.

As the shipper of this hazardous material and a representative of the United States Government, I am sure you have control over the railroad schedules should you choose to exercise it. As the agency responsible for transportation of radioactive materials, I am equally positive that the decision to ship three casks on one train was made in time to notify the affected cities of that decision.

Please use the powers of your office to persuade the railroads (Conrail and Union Pacific) to schedule these shipments at a more reasonable time; and please keep us informed about your plans to increase the number of casks carried in each shipment so we can plan for emergencies.

Sincerely,

Gay Carraway
Director of Public Safety

GC/af
cc: M. Jeffries, B. Kuehling, P. Hamsher, Cong. Clay, Cong. Buechner, Sen. Danforth, Sen. Bond, Ald. Aboussie

Department of Energy
Washington, DC 20545

January 22, 1988

Mr. Gay Carraway
Director of Public Safety
401 City Hall
City of St. Louis
St. Louis, Missouri 63103

Dear Mr. Carraway:

Thank you for your letter of December 22, 1987, about the shipment of spent fuel from Three-Mile Island (TMI) through St. Louis. I appreciate your interest and the concerns you expressed. Please be assured we have a mutual concern about protecting the health and safety of the public.

A third cask was put into service in November 1987 and is identical to the two casks used since the shipping campaign began in July 1986. It's built to the same high standards and design previously certified by the Nuclear Regulatory Commission. A three-cask train allows us to complete the TMI cleanup with fewer total shipments. Overall, safety is improved by having fewer shipments.

In my letter to you on October 14, 1987, I described how the public is protected by the extremely rugged cask. It's designed to protect the public even in very severe accidents, including high speed impacts. In both accidents and routine service, they're designed to strictly limit radiation exposure to people. The reduced speed shipments through St. Louis aren't a significant hazard to your citizens, rush hour commuters, or transport workers.

It may be helpful to describe radiation limits for Type B packages like the TMI casks. For any Type B package, external radiation must be less than 200 millirem/hour (mr/hr) at the package surface. It must also be less than 10 mr/hr at a distance of 1 meter from the package surface. These International Atomic Energy Agency standards have been adopted worldwide and by the United States to assure the public is protected. You may be aware we inspect every shipment before it leaves TMI and take radiation measurements. The maximum radiation detected from any of the three casks in our last shipment was only 4 mr/hr or only 2 percent of the allowable. The radiation dose to commuters from a passing train carrying this radioactive cargo is virtually too small to measure.

For rail transport, we seek to use direct routes to reduce transit time, good quality track, and carriers with experience in hauling hazardous cargo. On a long cross-country trip, arrival times in cities depend on what's happening along the route and can vary by several hours. So far, CONRAIL has been ahead of schedule and ahead of the rush hour. Only 4 of the 13 shipments have entered St. Louis after 7 a.m. We believe these shipments are safe at any hour of the day.

Concerning notification, Department of Energy policy requires 7-day written prenotification to States along the route. This notice was provided to Mr. Richard D. Ross by letter of December 11, 1987. Mr. Ross is the Director of Missouri's State Emergency Management Agency. It's my understanding your office was notified by Mr. Ross of the three-car shipment on December 21, 1987. We will continue our normal prenotification process, and we assume the State agency will keep you informed.

I believe the anxiety implied in your letter may be from a lack of information. I'm sending you some additional factsheets on transportation. Also enclosed is a recent press release which discusses our use of a third cask.

Again, I'm pleased to respond to your concerns.

Sincerely,

Lawrence H. Harmon, Director
Transportation Management Division
Office of Defense Waste and
Transportation Management
Defense Programs

2 Enclosures

cc:
Mr. Richard D. Ross

EXECUTIVE OFFICE
STATE OF MISSOURI

JOHN ASHCROFT
GOVERNOR

December 31, 1987

Honorable John S. Herrington
Secretary, U.S. Department of Energy
Forrestal Building, Room 7A-247
1000 Independence Avenue, S.W.
Washington, D. C. 20585

Dear Mr. Secretary:

The purpose of this letter is to inform you of my deep concern regarding the recent shipment of nuclear waste from the damaged reactor at the Three Mile Island (TMI) nuclear power facility through the St. Louis, Missouri, metropolitan area at the height of the morning rush hour.

As you surely know, the shipments of the TMI waste have, from the beginning, been a source of distress for many Missouri citizens who live in proximity to the rail shipment route. As you also may know, one of the early shipments was involved in a rail crossing accident with a motor vehicle in the St. Louis area.

Thus, it was with dismay that my staff learned that the first three-car shipment would pass through the St. Louis area during the 7:45 a.m. rush hour on December 22. While this shipment, in fact, passed safely through the state, its passage through a major metropolitan area during rush hour increased the risk of public exposure in the event of an accident.

As Governor, I want to do everything within my authority to control the risk to Missouri citizens attendant to the TMI shipments. Accordingly, I have sent state officials to examine the casks and shipment cars prior to the initial shipment, have required radiological monitoring upon entering and departing Missouri, and have used state public safety personnel and equipment to observe passage through the state. I have given advance notice to concerned communities of shipment times and dates. All of this has been done at state expense to safeguard the citizens of Missouri from the risks of a federal hazardous material shipment.

In my view, the shipment through St. Louis, Missouri, during the morning rush hour on December 22 was made in callous disregard of the very real concerns of Missouri citizens regarding the TMI shipments. I urgently request that you instruct DOE personnel and contracting agencies to seek shipment routes that

P.O. BOX 720 JEFFERSON CITY, MISSOURI 65102

Honorable John S. Herrington
Page 2
December 31, 1987

as far as possible avoid densely populated areas and, in the event shipment must pass through such areas, that the shipment be scheduled in such a manner as to reduce exposure risks to the minimum.

I ask for your assurance that these concerns will be addressed.

Sincerely,

John Ashcroft

GOVERNOR

bbs

The Secretary of Energy
Washington, DC 20585

MAR 1 1 1988

Dear Governor Ashcroft:

Thank you for your letter regarding the shipment of spent fuel from Three-Mile Island (TMI) through Missouri. I share your concerns about safety and assure you that the Department of Energy is committed to conducting these shipments in a manner that protects the public health and safety and the environment.

As you know, in response to concerns from you and Senator Danforth, the Department has acted to rectify the problems you have noted, particularly the major concern of rush-hour transit of St. Louis. To this end, it is our intention to work with the rail carriers and the Department of Transportation (DOT) to avoid the 6:30 a.m. to 9:30 a.m. and 3:30 p.m. to 6:30 p.m. periods. Inspections will be intensified in East St. Louis, and there will be no switching of buffer cars or the caboose. Union Pacific will assign management personnel to accompany the train through St. Louis to monitor speed. DOE will assign additional people to the train to monitor safety. To minimize the number of shipments, all future shipments will be consolidated with three casks each.

DOE will also conduct additional emergency response training in Missouri. This is intended to clarify State, local, and Federal roles. It will also better inform officials and first responders about DOE and rail carrier emergency response capabilities.

Finally, the Department of Transportation will conduct an independent routing analysis. Since this analysis could take several months, we will continue shipments while it is being completed. However, we will not ship until the Federal Railroad Administration completes its investigation of the East St. Louis events.

It is my hope that close cooperation will continue between the Department and the State of Missouri. If I can be of further help, please do not hesitate to contact me.

Yours truly,

"Original Signed By"

John S. Herrington

Honorable John Ashcroft
Governor of Missouri
Jefferson City, Missouri 65102

Jim Ferlo Member, Council
City of Pittsburgh

Room 510
City - County Building
Pittsburgh, Pa. 15219

August 4, 1988

Richard D. Sanborn, President
Consolidated Rail Corporation
Room 1846
Six Penn Center
Philadelphia, PA 19103

Dear Mr. Sanborn:

On behalf of the residents of the City of Pittsburgh, I would appreciate your assistance in resolving issues raised by the transportation of all the reactor fuel from Three Mile Island Unit 2 (TMI-2) in Middletown, Pennsylvania, to the Idaho National Engineering Laboratory (INEL), a federal laboratory located in Idaho Falls, Idaho. I understand that Conrail is responsible for shipping the materials to St. Louis, Missouri, where the railcars are transferred to the Union Pacific Railroad.

The City of Pittsburgh, in common with all other municipalities along the route, has no capability to respond to a transportation accident involving the TMI-2 fuel. For that reason, I am very concerned about why all the reactor fuel is being moved from the TMI site before a repository is available for its disposal. As reflected by the enclosed documents, Congress authorized the Department of Energy (DOE) to take possession of and title to approximately 15 percent of the TMI-2 fuel for purposes of "research" (Attachment A) while General Public Utilities (GPU) was required by the Nuclear Regulatory Commission (NRC) to store the balance of the fuel (85 percent) at the TMI site in sealed containers under provisions of the Nuclear Waste Policy Act (Attachment B). A government contractor confirmed earlier this year that only "samples" of the TMI-2 fuel are used for research purposes (Attachment C).

Apparently, however, 100 percent of the TMI-2 fuel will be taken to INEL although Congress only authorized DOE to receive samples (15 percent) for research. It is unclear how DOE is authorized to remove the remaining 85 percent. Both houses of Congress failed to act on legislation in 1982 which would have authorized federal storage under provisions of the Nuclear Waste Policy Act because TMI-2 is not an operating reactor with insufficient storage space (Attachment D). Further, under that same legislation, the Secretary of Energy is not empowered to take title to 85 percent of the TMI-2 fuel not authorized for use in research, and transport it to INEL because a federal repository is not constructed, licensed and available for use at this time (Attachment E).

The transfer of this 85 percent of the TMI-2 fuel from General Public Utilities to EG&G Idaho, Conrail and the Union Pacific Railroad apparently is subject to NRC regulations, specifically the requirements for an "independent spent fuel storage installation" (10 C.F.R. Part 72). I am not aware that INEL is licensed by the NRC for the Storage of commercial reactor fuel, and therefore do not understand how applicable regulations (10 C.F.R. S72.6) (Attachment F) allow all the TMI-2 fuel to be transported by Conrail and the Union Pacific Railroad to INEL. My concern is that insurance coverage for the fuel owned by GPU may not apply if the fuel removal is not consistent with federal regulations.

Your observations on these two issues -- (i) the applicability of federal regulation 10 C.F.R. S72.6 to Conrail's transportation activities involving the 85 percent of the TMI-2 fuel not authorized for research and (ii) the nature of the insurance coverage for this 85 percent portion of the fuel in transportation activities through the City of Pittsburgh -- would be very helpful. Thank you in advance for your consideration of these matters.

Sincerely yours,

Jim Ferlo

enclosures

cc: City Council
Mayor Masloff
Dan Pellegrini, Solicitor
Various municipalities and officials

CONRAIL

RECEIVED

SEP 1 _ 1988

Action		File

[RIC]HARD D. SANBORN
PRESIDENT AND
CHIEF OPERATING
OFFICER

August 25, 1988

The Honorable Jim Ferlo
Member, Council
City of Pittsburgh
Room 510
City-County Building
Pittsburgh, PA 15219

Dear Councilman Ferlo:

I am writing in response to your letter of August 4, 1988, in which you request Conrail's assistance in resolving a number of questions on the transportation of fuel elements from Three Mile Island.

You inquire as to the percentage of fuel being transferred from TMI Unit 2 to the Idaho National Engineering Laboratory (INEL) in Idaho Falls, Idaho; whether INEL is licensed as an independent spent fuel storage installation to accept more than 15% of the TMI Unit 2 fuel; and whether there is any impact on insurance coverage.

Conrail, as you know, is a common carrier by rail and the ICC has held, over the railroads' objections, that as such it must transport such items as spent fuel. Additionally, Conrail does not have the necessary information to respond to your questions. Therefore, questions concerning amounts of fuel to be transferred, licensing of destination sites, and insurance coverage are probably best answered by the United States Department of Energy (DOE) which takes title to the fuel upon its departure from the reactor site.

Conrail has worked with the DOE and its contractor EG&G Idaho, Inc. on the transportation of the Three Mile Island fuel, insofar as Conrail is concerned. Conrail is satisfied that its portion of the movement fully complies with all applicable laws and regulations and that the insurance coverage afforded by the Price-Anderson Act remains in place.

CONSOLIDATED RAIL CORPORATION SIX PENN CENTER PLAZA PHILADELPHIA, PA 19103-2959

As to your other questions, I have taken the liberty of forwarding copies of your letter to the appropriate representatives of the DOE and EG&G listed below for a further response, and I have been advised that their responses will be forwarded directly to you.

Very truly yours,

Richard D. Sanborn

cc: Mr. Lawrence Harmon
U. S. Department of Energy
D. P. 121
Transportation Management Division
Germantown, MD 20874

Mr. R. Dix Hoffman
U. S. Department of Energy
Idaho Operations Office
785 DOE Plaza
Idaho Falls, ID 83402

Mr. Al A. Anselmo
EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415

STATE OF ILLINOIS

DEPARTMENT OF NUCLEAR SAFETY

1035 OUTER PARK DRIVE
SPRINGFIELD 62704
(217) 785-9900

TERRY R. LASH
DIRECTOR

March 9, 1988

Mr. A. A. Anselmo
Traffic Manager
EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415

Dear Al:

Terry Smith, from EG&G Idaho called me on March 4th inquiring about a possible stopping point in Illinois for the TMI trains so that the trains don't go through St. Louis during rush hour traffic. I told him it wasn't a good idea because of the concern about anything nuclear along the route in Illinois and because of the long delays already occurring in Illinois. I suggested the train schedule be modified to avoid rush hour in St. Louis. My Director, Terry Lash, will not allow me to reply to Terry Smith's request because he intends to reply himself, probably to the Secretary of Energy.

To give you the true flavor of the public opinion along the route in Illinois about anything nuclear I have enclosed one week of clippings from the newspapers in the area. Please note that most of these papers are quite small. The only current sites for Illinois' new low-level waste disposal site are in this area of Illinois, thus there is tremendous interest and strong opinions about anything nuclear in this area. Please give these clippings to Terry Smith after you are finished with them so he can better understand local opinion along the route.

Sincerely,

Robert A. Lommler
Chief, Div. of Inspection & Operations

Mrs. Leo Drey
515 West Point Avenue
University City, MO 63130

April 13, 1988

Mr. Lawrence H. Harmon, Director
Transportation Management Division
Office of Defense Waste and
Transportation Management
Defense Programs
U.S. Department of Energy
Washington, DC 20545

Dear Mr. Harmon:

Debra Wilson of Citizens Against Radioactive Transport asked that I respond to your letter of March 24. She thanks you for your letter and for returning a copy of the train derailment article she circulated at the Energy Department briefing on the Three Mile Island fuel shipments held on March 23 in Washington. As Debra said to Congressman Jack Buechner, the Missouri mayors, Congressional staff people, and DOE representatives in attendance, our organization continues to be concerned about these shipments -- and particularly about the condition of the fuel debris now being extracted from the lower portions of the TMI reactor vessel. The deeper the excavation goes, the more unpredictable and unstable the retrieved material is. That's the kind of stuff that's been coming through our communities -- as recently as yesterday morning.

We continue to hope that Congressman Tom Luken's Transportation Subcommittee will hold an oversight hearing, as requested by Congressmen Bill Clay and Dick Gephardt, on the legality and safety of these shipments.

The DOE's reassurances about the safety of the shipments are based almost entirely on the integrity of the casks. And yet, according to an advertisement placed by the manufacturer in Nuclear News, July 1986, the casks for the TMI fuel were designed, built, and approved for use "in record time."

The Nuclear Regulatory Commission, which is responsible for setting standards for commercial fuel casks, chose certain accident conditions which certified casks are supposed to be able to survive intact (or with only "permissible" leakage). We do not believe that the NRC's criteria for testing the ability of a spent fuel cask to withstand accident conditions are adequate; in the case of the casks and canisters designed and fabricated specifically for the melted TMI fuel and related equipment, we believe these inadequate testing requirements were either performed insufficiently or not at all.

The only real tests performed on a TMI cask (on a quarter-scale model) were drop and puncture tests. We have seen no evidence that a TMI cask was subjected to an immersion test -- that is, to immersion in three feet of water for eight hours. And yet as a result of the train derailment described in Debra's January 27 St. Louis Post-Dispatch article, many of the cars that fell off the 40-foot-high trestle landed on the river bank, only feet away from the Meramec River. If a TMI cask were to fall in a river, no one can predict how much water might enter the cask. As you know, the potential of water inleakage increases the risk of a criticality accident -- that is, an uncontrolled nuclear chain reaction. According to a New York Times article (January 26, 1988; p. 17), as little as 150 pounds of the TMI fuel debris could become critical. In each of the three most recent shipments through St. Louis -- December 22, February 9 and April 12 -- an estimated 30,000 pounds of TMI fuel passed over the same trestle involved in the January 26 accident here in St. Louis County. According to a preliminary Union Pacific report, the derailment was caused by a broken wheel on the 64th car. As quoted in the Post article, a Union Pacific spokesman maintained that the rail track was "in good condition."

According to testimony presented to a Senate Commerce subcommittee on July 20, 1979, by a vice president of the Association of American Railroads, the NRC's test conditions for casks do not "insure compatability with actual operating conditions." Specifically with respect to the NRC's fire testing requirements:

> ... the threat of a fire of extended duration is always present in a railroad accident. ... A fire of 30 minutes duration at 1,475^{O}F [the NRC's fire test conditions] is probably not sufficient to seriously damage a spent fuel cask. However, the railroads estimate that the lead shielding would become molten in one-and-a-half to two hours in a fire of about 1,475^{O}F. This estimate has been confirmed by an Energy Research and Development Administration [the DOE's predecessor agency] test conducted by Sandia Laboratories. In that test an empty cask was submerged in a pool fire. The lead became molten, leaving unshielded areas, in less than two hours. This happened despite the fact that the cask used in the test was empty and, thus, not exposed to internal as well as external heat.

As questionable as the NRC's fire standard may be, the TMI fuel cask was only subjected to fire testing by computer simulation. The reason Debra circulated the January 27 Post article and its accompanying photographs was to challenge the DOE's assertion at the briefing that a cask could not possibly end up suspended in the NRC's hypothetical fire of 1475^{O} for a half-hour. As the photo indicates, railcars were indeed left dangling from a railroad trestle over a fire, and in fact the fire continued to burn more than six hours.

Furthermore, according to an NRC report prepared for the public on the ability of spent fuel casks to withstand actual transportation accident conditions ("Transporting Spent Fuel," March 1987), recorded data do not exist on "the location of a cask relative to a fire resulting from a transportation accident." According to the same report, historical data on the temperatures and durations of transport fires do not exist either. Therefore the estimates in the NRC study of cask damage caused by fire had to be based on computer estimates and even on "a presumption." (p. 21; emphasis added.)

We also have no assurance that anyone can predict with any accuracy the rates at which steam and combustible gases are being generated within the canisters and therefore within the cask interior. As I said at the beginning of this letter, the deeper into the vessel the workers chip away, the more our concerns grow. Every canister contains its own unpredictable hodge-podge of radioactive fission, activation and corrosion products in pieces that are in unknown geometric configurations, emitting radioactive particles and rays at unpredictable rates, bombarding an unpredictable amount of residual water entrapped during the loading of the canister. Catalytic recombiners had been designed for the canisters to try to prevent a combustible gas mixture -- and hence, a potential hydrogen explosion -- as the result of the interaction of the radioactive materials with the water. However, according to a December 12, 1986, letter from the NRC to General Public Utilities, the owners of Three Mile Island, the recombiners were not installed according to specifications.

One request: the only tests we know about to determine the rate at which combustible gases are being generated were performed on six of the early canisters filled with loose TMI core debris and shipped to Idaho; only one of the six canisters contained, in addition, pieces of fuel rods. These materials are certainly different from the wastes extracted from the deeper layers of the reactor vessel where melted fuel rods and control rods had migrated. If you know of any more recent tests regarding gas generation rates -- or if you know of any tests of the effectiveness of the recombiner catalysts in the TMI canisters -- I would greatly appreciate learning about them, or if possible, receiving a copy of the results.

The above discrepancies and uncertainties about the casks are among the topics we hope will be addressed in a Congressional oversight hearing.

Sincerely,

Kay Drey

Department of Energy
Washington, DC 20545

MAY 2 3 1988

Mrs. Leo Drey
515 West Point Avenue
University City, MO 63130

Dear Mrs. Drey,

I'm responding to the concerns expressed in your April 13, 1988, letter about the Three-Mile Island (TMI) shipments. I'm afraid you have either been misinformed or have misinterpreted the information available. Your letter quite correctly assumes the primary protection for the public is provided by the shipping cask. It's a fundamental concept imbedded in the regulations as originally developed by the National Academy of Sciences in the mid 1940's. Furthermore, that same concept is the underpinning of the international regulations and, therefore, the regulations of all other countries in the world. Only by such an approach can the dependence upon administrative requirements (where the system is subject to human error) be avoided. Therefore, a great effort goes into design of these systems and Nuclear Regulatory Commission (NRC) evaluation of them. NRC can typically review an application (which includes a very complete safety analysis by the designer) in about a year. Because of the workload, they don't always achieve that goal. Because the TMI program had such a high national priority, we asked NRC to put this application ahead of all of our other packagings then under review. That, plus the fact the designer (Nuclear Packaging) had done such an outstanding job of design and documentation, enabled the NRC to complete its work in less than a year. Thus, the manufacturer (i.e., the designer) was quite right in claiming credit for "designing, fabricating, and delivering" the cask "in record time." The 17 months referred to in the add did not include NRC review time. In contrast to the conclusion you reached, the "record time" was in large measure a reflection of the quality of the design which was clearly the thrust of the advertisement.

You go on to state, "We do not believe that the NRC's criteria for testing the ability of a spent fuel cask to withstand accident conditions are adequate." Yet, a series of engineering studies performed by several reputable firms for NRC has consistently found the criteria are not only adequate, but quite conservative. Further, the criteria, in existence in their present form for about 40 years, have been found to be adequate by a large number of other countries and the International Atomic Energy Agency. Worldwide experience in transporting high-level radioactive materials using these packagings have resulted in NO releases of material in any transportation accident. How "adequate" must the criteria be?

Then you state, "we believe these inadequate testing requirements were either performed insufficiently or not at all." The very same advertisement you referenced before states "after rigorous testing" NRC approval was gained. Evidently, you object to the use of one-quarter scale models for testing in spite of the fact this is a well-established engineering methodology. The 125B cask was tested at one-quarter scale by Sandia and found to be a very competent system. With exception of very localized deformations at the point of impact, the cask behaved elastically when subjected to these regulatory tests. In other words, there was no overall distortion of the cask and, therefore, no threat to the seals that prevent radioactive materials from escaping. This cask is very different from other spent fuel casks. Because of the nature of the material to be transported (i.e., the disrupted core), this cask was designed with double containment. Thus, for radioactive material to "leak out" of this system it must somehow manage to pass through two seals or through two separate containers.

You go on to say, "We have seen no evidence that a TMI cask was subjected to an immersion test -- that is, to immersion in three feet of water for eight hours." Two considerations are of importance here. First, this doubly-contained system was pressure-tested to 1.5 times the maximum expected pressure that might develop as a result of being sealed for 1 year. Thus, the 125B was pressurized to 188 psig as a part of its acceptance inspection. Immersion under 3 feet of water will produce pressures of less than 10 psig. Obviously, immersion is not a real threat to the integrity of the cask. Second, the NRC regulations require the cask be designed to accommodate flooding. Criticality must be evaluated under "optimal hydrogenous moderation." In simple terms, that means the fuel material must be considered to be in powder or granular form suspended in water for the purpose of criticality calculations. The contents may be kept subcritical by either geometry or poisons. In the 125B, neutron poisons are built in to assure subcriticality under all conceivable conditions. Therefore, the quantity of TMI spent fuel passing over a trestle (in multiple casks) has no bearing on the criticality question.

You next object to both the thermal test criteria and to the fact the TMI cask has not been tested full scale. Let me repeat what I stated in my letter to Ms. Wilson of Oakland, Missouri. The thermal requirements a Type B package must meet are quite rigid. They're also applied after the free-drop and puncture requirements (i.e., the already damaged package must survive the thermal test). The specific thermal requirements of 10 CFR 71.73 are as follows:

> "(3) <u>Thermal</u> - Exposure of the whole specimen for not less than 30 minutes to a heat flux of not less than that of a radiation environment of 800°F (1475°F) with an emissivity coefficient of at least 0.9. For purposes of calculation, the surface absorbtivity must be either that value which the package may be expected to possess if exposed to a fire or 0.8, whichever is greater. In addition, when significant, convection heat input must be inclyded on the basis of <u>still</u> (emphasis added), ambient air at 800°F (1475°F). Artificial cooling must not be applied after cessation of external heat input and any combustion of materials of construction must be allowed to proceed until it terminates naturally. The effects of solar radiation may be neglected prior to, during, and following the test."

As I explained to Ms. Wilson, these criteria closely replicate the thermal conditions at a point about 4 feet above the fuel surface in a very large gasoline fire (which burns at about 2,000 to 2,200°F). Five conditions must exist before such a fire can occur. First, there must be a source of fuel. In rail transportation scenarios there is certainly fuel available, on some occasions, to create fires of the gasoline variety. Second, there must be a co-location of the fuel and the cask. Again, it is possible the fuel might end up adjacent to or under the cask following an accident, but the probability is significantly less than that of there being fuel available. Third, there must be enough fuel to support combustion of a very large fire (on the order of 30 by 50 feet in surface area) for the time period of importance. Assuming the fuel is contained in a sealed 30 X 50-foot pit, a 30-minute fire would require about 9,000 gallons of fuel (gasoline). But, such conditions simply don't exist in real life. Instead, the pit (if it exists at all) will be larger (a smaller area presents less threat to the cask), won't be sealed (meaning that fuel will soak into the ground), will not provide containment (meaning that fuel will run out and away from the main fire), or any combination of these. Under such conditions, the fuel requirement will climb to at least 36,000 gallons and likely even higher (this fourfold increase is based only upon fuel being absorbed by the soil). Fourth, the cask would have to end up supported about 4 feet above the fuel with very little structure surrounding it. Further, the structure would have to survive the fire and keep the cask suspended so the regulatory conditions could be maintained. Fifth, there must be no (repeat no) wind or the flames will be blown away from the cask and the thermal input drastically reduced. Since all of these conditions must exist and each is a chance condition, the probability of achieving all five is vanishingly small. Repeated studies by various engineering organizations worldwide using various methodologies, have concluded the thermal criteria are indeed sufficient to encompass essentially all transportation-related fires.

As you point out, the exposure of one of these casks to a fire of less than 2-hour duration resulted in the lead shielding becoming molten. But, in spite of the information that you apparently have been given, this did not result in "leaving unshielded areas." In the Sandia full-scale test, melting of the lead was complete at about 90 minutes after the fire began. At 120 minutes into the test, the structure supporting the cask above the flames became so softened by the heat that it sagged and the cask rolled off into the fuel pit. When that happened, the thermocouples which had been placed deep within the lead to monitor temperature (which is how it was known that the lead was molten) were pulled out. This left a series of holes about 1/4-inch in diameter through the outer stainless steel skin of the cask. These holes were drilled for the instrumentation for the thermal test, so represented a nonstandard condition. Originally these holes were along the upper centerline of the cask and were sealed by threaded fittings. When the cask rolled off of its supports, the fittings were pulled out and the cask rotated 90 degrees so that these open holes were along the side of the cask instead of the top. As you would expect, molten lead poured out of these holes and mounds of solidified lead were found on the bottom of the fuel pit after the test. Eventually, the lead in the cask body solidified and the loss stopped. Even under this very unrealistic condition, the lead loss resulted in a reduction of only about 4 inches in the shielding along what was then the upper centerline of the cask. Any radiation leakage would have been directed upwards and the increased radiation level at the top surface of the cask would have exceeded regulatory limits following an accident only very slightly.

The fact that the cask tested did not have an internal heat load is true, but again misleading. Spent fuel, such as is being moved out of TMI, is quite old (about 10 years) and, thus, generates very little heat (it is limited to 100 watts per canister). Assuming that it should produce as much as a 100 kilowatts, that still is inconsequential in comparison to the hundreds of megawatts generated by the test fire. An increase of an additional one part in a thousand to the heat input wouldn't change the results detectably.

Your objection to the use of calculational techniques rather than full-scale testing in evaluating the cask's thermal response is again unsurpassed. The whole purpose of the test program that Sandia conducted for the DOE was to evaluate the accuracy of computer simulation when compared to a full-scale test. The primary result of that test program was the conclusion that analytical techniques are indeed accurate and capable of predicting response of structures, such as spent fuel casks, to both mechanical as well as thermal environments.

But, perhaps your greatest misuse of the data is your claim concerning page 21 of the NRC publication, "Transporting Spent Fuel," published in March 1987. You state, "Therefore the estimates in the NRC study of cask damage caused by fire had to be based on computer estimates and even on 'a presumption.'" If you read that page, the presumption is that in every accident in which there is a fire, that fire will be within 31.5 feet of the cask. That presumption is obviously false since some accidents will occur in which there is a fire, but it will be further away than 31.5 feet. Evidently, in your zeal to find fault you keyed on the word "presumption" and didn't read the text. In this case, as technical people try always to do, the presumption was selected to make the situation more severe than reality.

All in all, your concept of fires is somewhat mixed up. True, some fires do burn longer than 30 minutes and, in fact, there are rail fires that have burned for 6 or more hours, but you haven't included the whole picture. One of the very long fires the rail industry likes to cite as an example is the one that took place at Livingston, Louisiana. That fire burned for several days, but not at the same location the whole time. During the course of the fire, it moved around from one fuel source to another. The shipping cask cannot move around to stay within the fire. The Modal Study, in fact, studied that fire and concluded it would not have threatened the integrity of a spent fuel shipping cask. And, there are fires that burn hotter than the regulatory specifications; but temperature is only one criteria. Time is the other criteria, and fuels that burn hotter than gasoline also consume more fuel, thus requiring larger volumes to achieve the same burn time. A simpler way to achieve hotter fires is to confine the flames so that the radiant heat is reflected back into the cask. For example, the Caldecott Tunnel fire in 1982 created temperatures slightly in excess of 1900^{0}F in structures in the vicinity of the accident. Again, the Modal Study evaluated that fire and found that it would also not have resulted in failure of a spent fuel shipping cask since, while quite hot, the fire did not last long enough to raise the enormous mass of a shipping cask to failure temperatures.

Finally, the matter of gas generation. You state in your letter that "We have no assurance that anyone can predict with any accuracy the rates at which steam and combustible gases are being generated within the canisters and therefore within the cask interior" (emphasis in the original). Again, your information is inaccurate. When shipments began from TMI, a series of canisters were extensively tested. Those tests began with storing the loaded canisters for a period of 2 weeks in the pool at TMI. After 2 weeks, the gas in the canister was tested and compared with the results obtained at the time of closure and then reinerted. Then the canisters were shipped to Idaho where they were again sampled for gas to determine the effect of the shipping environment. After the canisters were stored in Idaho for 6 weeks, they were sampled again. The result of this test program was the hydrogen generation detected was only about 10 percent of what had been predicted. In addition, none of these tests produced gasses in the canisters which were anywhere near combustible limits. In other words, gas generation could increase by at least a factor of 10, and these shipments would still be safe. As a result, the NRC has found the gas generation concern has been adequately addressed.

Your claim that the NRC found that "the recombiners were not installed according to specifications," is not correct. In the December 12, 1986, letter you reference, the NRC concurred with GPU that even though there was one specific orientation in which less than 50 percent of the recombiners might be exposed to the void volume of the canister, that the margin of safety was so large that the reduction to 33 percent was not a significant safety problem. The letter makes no reference to the recombiners not being installed according to specifications or any other problem with the quality of these canisters as you imply.

One other facet of yours about gas generation involves the water remaining in the cask prior to shipment. After loading this material into the canister, essentially all of the water is removed through a dewatering process. Coupled with the fact that there is little residual water, the maximum calculated internal temperature (created during the design basis fire environment) is only 167°F, not high enough to boil water or create steam (the margin is even higher when the internal pressure of the cask is taken into account). All of this has been carefully reviewed and concurred in by the NRC. Even in the material now being removed from the lower portion of the core region, the water is removed before shipment.

It should be of some assurance to you that each canister, as it is sealed, is sampled for gas content to ensure that a combustible gas mixture will not develop within the canister in twice the time anticipated for canister shipment. In none of the canisters filled with debris to date have we measured any gas concentration which would indicate that this limit would be approached in even longer times. The gas generation rates are far less than anticipated and the recombiners perform better than expected. I would hope this information might ease your mind about the safety of these canisters and the material they contain.

Mrs. Drey, I appreciate your concerns and I hope I have given you the information you need to alleviate those worries. We at DOE are also concerned about the safe shipment of these and all radioactive materials. We do take great care in handling these materials because we too recognize the hazards involved.

Sincerely,

Lawrence H. Harmon, Director
Transportation Management Division
Office of Defense Waste and
Transportation Management
Defense Programs