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Battelle

Pacific Northwest Laboratories
Richland, Washington 99352

AEC Research and Development Report

PROCEEDINGS OF THE THIRD INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

AUGUST 16-20, 1971
RICHLAND, WASHINGTON, U.S.A.

BNWL-SA-3906

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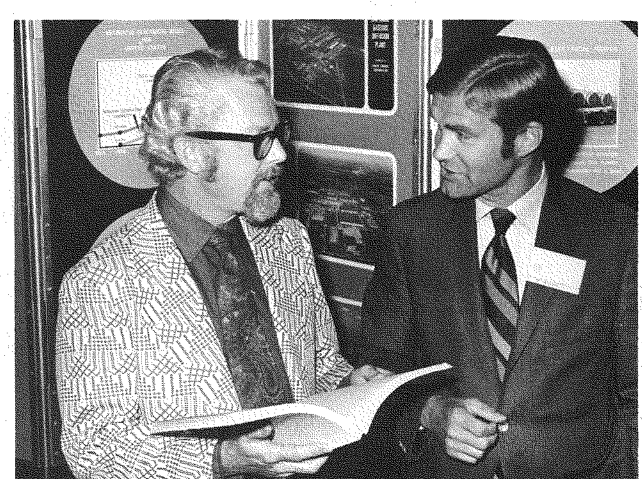
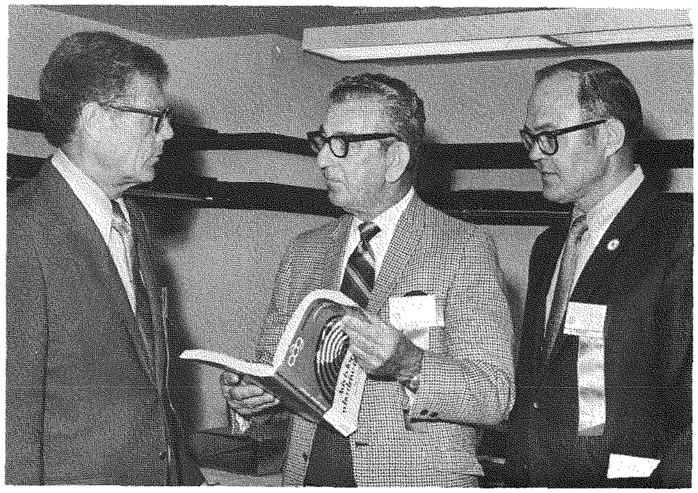
CONF-710801--(Vol. 3)

PROCEEDINGS OF THE THIRD INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

This is Volume 3 of the Proceedings of the Third International Symposium on the Packaging and Transportation of Radioactive Materials. Volumes 1 and 2 were published as CONF-710801 and are available from NTIS, 5285 Port Royal Road, Springfield, Virginia.

Richland, Washington
August 16-20, 1971



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MORROW

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THIRD INTERNATIONAL SYMPOSIUM

PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

AUGUST 16-20, 1971/RICHLAND, WASHINGTON, U.S.A.

Sponsored by the U.S. Atomic Energy Commission, Richland Operations and the following contractors:

- Atlantic Richfield Hanford Company
  A subsidiary of the Atlantic Richfield Company
- Battelle—Pacific Northwest Laboratories
  A division of Battelle Memorial Institute
- Douglas United Nuclear, Inc.
  A subsidiary of McDonnell Douglas Corp. and United Nuclear Corp.
- ITT/Federal Support Services, Inc.
  A subsidiary of International Telephone and Telegraph Corp.
- J. A. Jones Construction Company
- Vitro Engineering Services
  A division of Vitro Corporation of America
- WADCO Corporation
  A subsidiary of Westinghouse Corporation

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	Charles Goodner	USAEC-RL
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AECB-Canada	— Atomic Energy Control Board, Canada
ARHCO	— Atlantic Richfield Hanford Company
BNW	— Battelle—Pacific Northwest Laboratories
DUN	— Douglas United Nuclear, Inc.
ITT	— ITT/Federal Support Services, Inc.
JAJ	— J. A. Jones Construction Company
ORNL	— Oak Ridge National Laboratory
USAEC-HQ	— U.S. Atomic Energy Commission, Headquarters
USAEC-RL	— U. S. Atomic Energy Commission, Richland Operations Office
Vitro	— Vitro Engineering Services
WADCO	— WADCO Corporation

THIRD INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

August 16-20, 1971
Richland, Washington

General Information

Richland, Washington, is the site for the Third International Symposium on the Packaging and Transportation of Radioactive Materials. Technical sessions will be held concurrently in the Hanford House Convention Center and the Federal Building Auditorium. Exhibits are located throughout the convention area.

Registration

The symposium registration fee is $50.00. Payment provides the attendee admission to all of the technical sessions, special events, and receipt of a copy of the Symposium Proceedings.

Headquarters for the Symposium is the Hanford House, Richland, Washington. Registration hours are from 1 to 7 PM on Sunday, August 15; from 8 AM to 5 PM on Monday, August 16; and from 8 AM to 12:00 noon on Tuesday, Wednesday and Thursday.

Transportation

Air and rail travel reservations are made to and from Pasco, Washington. The Pasco airport and rail station serve the Tri-Cities area of Kennewick, Pasco and Richland. The Tri-City Limousine Service meets all planes and provides transportation to all motels.

A travel officer will be stationed at meeting headquarters to make, change, or cancel travel arrangements, as needed.

For the information of motorists, the Tri-Cities are located on U.S. Highways 12 and 395; and are approximately 150 miles south of Spokane, Washington, and 200 miles inland from both Portland, Oregon, and Seattle, Washington.

Rental cars are available from Airways, Avis, Hertz, National and Thrifty. Bus transportation will be provided between motels and symposium headquarters at no cost to attendees.

Housing/Accommodations

The housing committee has served as a clearing house for motel accommodations. The committee reserved blocks of rooms at some ten motels in the Tri-Cities. Rooms were assigned on a first come, first served basis. Room rates range from $9 to $15/single to $11 to $20/double.

Ladies' Program

A special program is planned for the ladies. Activities have been arranged to allow ample free time. The program is:

Monday - August 16

2:00 - 4:00 PM

	Host:
Get-Acquainted-Tea at the Hanford House	Vitro Engineering

A short program to acquaint the ladies with the Tri-Cities Area and outline scheduled activities (no charge).

6:00 - 8:00 PM

Get-Acquainted-Mixer at the Hanford House for Symposium participants—the ladies are cordially invited (no charge).	Atlantic Richfield Hanford Company

Tuesday - August 17

1:30 - 3:30 PM

Art Tour — A guided tour of the Jaid Gallery with a demonstration of pottery making on the wheel.

6:00-7:00 PM

Host:

Social Hour — Rivershore Motor Inn

For the Symposium participants—the ladies are cordially invited (no charge).

Host: WADCO Corporation (A subsidiary of Westinghouse Electric Corporation)

7:00 PM

Symposium Banquet — Rivershore Motor Inn. Ladies are invited to attend ($6 per guest).

Symposium Committee

Wednesday - August 18

12:45 - 4:40 PM

Tour of Hanford Complex — Ladies are invited to tour the Hanford Science Center

Thursday - August 19

11:00 AM - 4:00 PM

Sightseeing tour to Indian Artifacts Museum at Sacajawea Park and to Ice Harbor Lock and Dam (no transportation charge, refreshments available at the park).

6:00 PM

Host:

Social Hour — Hanford House

Battelle —Pacific Northwest Laboratories

For Symposium participants—the ladies are cordially invited (no charge).

7:00 PM

Smorgasbord — Hanford House

Douglas United Nuclear, Inc.

For Symposium participants, the ladies are cordially invited (no charge).

Friday - August 20

No scheduled activities

Tours During Symposium

Tours are planned for participants and families. Preregistration is required for all tours. Registration for the tours will be handled at the Registration desk during normal registration hours.

*   *   *

TOUR "A" Hanford Science Center conveniently located in the Federal Building directly across the park from Richland's Hanford House. Allow about 1 hour for the entire tour between the hours of

1:00-6:00 PM & 7:00-9:00 PM Monday thru Thursday
1:00-9:00 PM on Friday & Saturday

his tour should be a prerequisite to any tour within the Hanford ʼroject.

The Science Center enables the visitor to visualize the operations carried out at the Hanford Project. **No charge - No age restriction - Preregistration not necessary.**

*   *   *

TOUR "B" "N" Reactor and Washington Public Power Supply System. Limited to symposium registrants only - No camera permitted.

Tour "B" buses will depart from the Hanford House entrance on Wednesday afternoon, August 18, 1971, at 12:45 PM and return at 4:40 PM. Will meet connecting buses on the return trip destined to all major motels.

Highlights of this tour will include seeing the first U.S. dual-purpose nuclear reactor, rated at 800,000 kilowatts of electricity. Other items of interest throughout the Hanford Works Project will be viewed during this tour.

* * *

TOUR "C" Ice Harbor Lock & Dam - Salmon fish ladders - Indian Artifacts Museum

This sightseeing tour offers a change of pace and is particularly designed for the pleasure of the wives and children of symposium registrants. Travel will be by air-conditioned bus (approximately 50 miles round trip), leaving Richland's Hanford House at 11 AM Thursday, August 19th, and returning at approximately 4:00 PM.

This tour will highlight the Indian Artifacts Museum at historical Sacajawea Park, located at the confluence of the mighty Columbia River with the winding Snake River. Ice Harbor hydroelectric power dam generates up to 540,000 kilowatts of electricity annually, and is one of many such dams in the area. Built-in fish ladders at this dam handle the annual migration of salmon and other anadromous fish to their spawning grounds each season. Huge locks assist the navigation of small pleasure craft as well as large barges which transport vast amounts of grain and petroleum on their way to market. These locks lift such barges and small boats 103 feet into Lake Sacajawea. Return bus is scheduled to discharge passengers at main motels in the Tri-Cities area. **All persons welcome.**

* * *

TOUR "D" WADCO's Nuclear Fuel Process Demonstration & Development Facility, 308 Bldg., & 324 Bldg., Limited to Symposium registrants only.

This tour is rather technical in nature and shows the development of the Fast Flux Test Facility fuel pins in connection with the Liquid Metal Fast Breeder Reactor program, the USAEC's Number One priority program. Plutonium oxide and uranium oxide are mixed to form this new type of reactor fuel. Various types of on-site and off-site casks may be seen during this tour. In addition, the tour also features a work location inventory and computerized criticality system. Bus will depart Richland's Hanford House at 1:15 PM, Wednesday, August 18th, and return at approximately 4:00 PM, connecting with buses to the main Tri-Cities area motels.

* * *

Films

Tuesday, August 17, 12:45-1:15 PM

Special Film: "The Endless Chain"
(First of two showings)

For: Attendees, **wives** and **families**
Location: Federal Building Auditorium

The story of an important ecological study on an isolated desert area of southeastern Washington State aimed at helping man learn how to live in harmony with his delicate, complex environment. An intimate look at the "endless chain of life" in the desert: the ceaseless transfer of the sun's energy to plants, to insects, to animals.

Courtesy of Battelle-Pacific Northwest Laboratories

Wednesday, August 18, 12:45-1:15 PM

Film: "Safety in Salt"
(Second showing; see Session 6B)

For: Attendees
Location: Federal Building Auditorium

Courtesy of Division of Waste Management and Transportation, U.S. Atomic Energy Commission

Thursday, August 19, 12:45-1:15 PM

Film: "First Class Return"
(Second showing; see Session 8B)

For: Attendees
Location: Federal Building Auditorium
Courtesy of British Nuclear Fuels, Ltd., Risley, Warrington, England

Friday, August 20, 12:45-1:15 PM

Film: "The Endless Chain"
(Also shown Tuesday, 12:45 PM)

For: Attendees, **wives** and **families**
Location: Federal Building Auditorium
Courtesy of Battelle—Pacific Northwest Laboratories

Exhibits

Several exhibits are located throughout the Symposium area. These exhibits show some of the advances in packaging technology; and, in general, indicate the state-of-the-art. The Symposium Committee extends a special thank you to those who have so generously brought these exhibits to Richland, and have made arrangements to display special packages. Exhibits and locations are as follows:

Subject	Courtesy of
Location: **Hanford House**	
Poster Display of Special Packages	Protective Packaging, Inc., Tacoma, WA, a subsidiary of Nuclear Engineering Co., Inc., Morehead, KY
UF_6 Packages and Handling Techniques	Oak Ridge National Laboratory and Paducah Gaseous Diffusion Plant, Paducah, KY, operated by Union Carbide for USAEC; Portsmouth Gaseous Diffusion Plant, Portsmouth, OH, operated by Goodyear Atomic Corp. for USAEC.
Fissile Material Packages and Packaging Techniques	The Dow Chemical Company, Rocky Flats Division, Rocky Flats, CO

Information on Packaging and Transportation	Nuclear Safety Information Center, Oak Ridge National Laboratory, Oak Ridge, TN
Retrieval System for Transportation Information	Battelle-Pacific Northwest Laboratories Richland, WA

Location: **Parking Lot South of John Dam Plaza**

Overpack Package (Super Tiger)	Protective Packaging, Inc., Tacoma, WA, a subsidiary of Nuclear Engineering Co., Inc., Morehead, KY
Radio Equipped Truck and Trailer	Tri State Motor Transit Co., Joplin, MO

Location: **Federal Building Lobby and Hall**

New Class I Package for Plutonium Nitrate Shipment	International Nuclear Company, Elizabethton, TN

Special Display of Fissile Material Packages

DOT 6M (DOT Specification)	ATCOR, Inc., Elmsford, NY
DOT 6L (DOT Specification)	ATCOR, Inc., Elmsford, NY
Model 10 (DOT-SP-5681)	WADCO Corp., Richland, WA
Model 30 (DOT-SP-5896)	Battelle-Pacific Northwest Laboratories Richland, WA
Model 55 (DOT-SP-4915)	WADCO Corp., Richland, WA
Model 60 (DOT-SP-6387)	WADCO Corp., Richland, WA
Model 2030-1 (DOT-SP-5332)	The Dow Chemical Company, Rocky Flats, CO
Model L3 (DOT-SP-5330)	Atlantic Richfield Hanford Company, Richland, WA
Model LLD-1 (DOT-SP-4960)	Atlantic Richfield Hanford Company, Richland, WA
Y-12 Foamglas (DOT-SP-5795)	Oak Ridge National Laboratory, Oak Ridge, TN
UKAEA Special Inner Container for Use with KKD-1 (LLD-1) Shipping System (DOT-SP-4960)	Atlantic Richfield Hanford Company, Richland, WA
DOT 12B (DOT Specification) with DOT Specification 2R container	Battelle-Pacific Northwest Laboratories Richland, WA

THIRD INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

August 16-20, 1971
Richland, Washington

PROGRAM

Monday, August 16
Hanford House Convention Center

9:30 AM **Opening of Symposium**

Welcome
L. F. Perkins, Special Assistant to Manager, USAEC, Richland, WA

Introductory Remarks
D. G. Williams, Manager, Richland Operations Office, USAEC, Richland, WA

Introduction to Hanford
L. F. Perkins

Program
C. L. Brown, Symposium Chairman, Battelle-Pacific Northwest Laboratories, Richland, WA

Introduction of Keynote Speaker
Dr. Frank K. Pittman, Director, Division of Waste Management and Transportation, USAEC, Washington, D.C.

Keynote Address
General Benjamin O. Davis, USAF (Ret.), Assistant Secretary for Safety and Consumer Affairs, U.S. Department of Transportation, Washington, D.C.

10:45 AM Intermission

Monday, August 16 (contd)

11:15 AM **SESSION 1. Radioactive Material Transportation in Perspective**
Hanford House Convention Center

Chairman: E. M. Johnston, Symposium Co-Chairman, WADCO Corporation, Richland, WA

SYMPOSIUM LEAD PAPER

Trends in Nuclear Transportation

E. B. Tremmel and R. J. Berte, Division of Industrial Participation, USAEC, Washington, D.C.

12:00 Noon Lunch

1:30 PM **SESSION 2. U.S. Regulations**
Hanford House Convention Center

Chairman: W. J. Burns, Director, Office of Hazardous Materials, U.S. Department of Transportation, Washington, D.C.

How Abnormal Is Normal?

J. A. Sisler, Division of Waste Management and Transportation, USAEC, Washington, D.C.

U.S. D.O.T. and I.A.E.A. shipping regulations specify procedures for evaluation of package integrity. Studies indicate these procedures do not represent the transport environment. New evaluation procedures are in preparation.

Today's Role of D.O.T. in Regulating the Transport of Radioactive Material.

A. W. Grella, Office of Hazardous Materials, U.S. Department of Transportation, Washington, D.C.

The development of the United States regulations is traced and presented in chronological fashion. The present regulatory functions and roles of D.O.T. are summarized in light of most recent and pending rule making proposals and actions.

Transportation Safeguards

D. L. Crowson, Office of Safeguards and Materials Management, USAEC, Washington, D.C.

This paper discusses the need for transportation safeguards, the magnitude of the problem and where we stand now

Improving Applications for Shipping Container Approvals

R L Stevenson Division of Materials Licensing, USAEC, Washington, D C

Methods to improve applications and avoid delays in licensing will be recommended The use of check lists, a broad description of package content, and quality assurance principles in both container design and applications for approval will be discussed

Brochure on Transport Regulations

A C Cornish, Bureau of Radiological Health, California Department of Public Health, Berkeley, CA and H Simens, Bechtel Corporation, San Francisco, CA

An 'action sequence' arrangement of the regulations governing transportation of radioactive materials

3 00 PM Intermission

3 30 PM **SESSION 3. International Regulations**

Hanford House Convention Center

Chairman A W Grella, Radiological Engineer, Office of Hazardous Materials, U S Department of Transportation, Washington, D C

1970 Review of I.A.E.A. Regulations for the Safe Transport of Radioactive Materials

G E Swindell, Radiological Safety Section, International Atomic Energy Agency, Vienna, Austria

Development of the I A E A Regulations is described with particular attention to the content of the 1970 draft revision Other recent work on the Agency in the areas of design, test, and review of packages is discussed

How Changes in I.A.E.A. Regulations May Affect 10 CFR Part 71

R F Barker, Product Standards Branch, Division of Radiation & Environmental Protection, USAEC, Washington, D C

Monday, August 16 (contd)

Department of Transportation and Atomic Energy Commission regulations substantially conform to the I.A.E.A. 1967 regulations. Impending changes in the I.A.E.A. regulations and effect upon U.S. regulations are described.

Particular Solutions to Meet Regulations Requirements
M. Redon, Direction des Productions, Commissariate a L'Energie Atomique, Fontenay-aux-Roses, France

Technological solutions to Type B packaging design problems are described.

USAEC Licensing for the Export of Radioactive Materials
J. D. Saltzman and C. J. Holloway, Jr., Indemnity and Export Control Branch, Division of State and Licensee Relations, USAEC, Washington, D.C.

The requirements and the mechanics necessary for obtaining an export license are discussed for the various forms of radioactive and fissile materials.

6:00 PM to 8:00 PM **Get-Acquainted Mixer**
Reception at Hanford House
(Host: Atlantic Richfield Hanford Company)

Tuesday, August 17

8:30 AM **SESSION 4A. Isotopes and Waste Packaging Technology (Part I)**
Hanford House Convention Center

Chairman: C. F. Goodner, Chief (Ret.), Traffic Management, USAEC, Richland Operations Office, Richland, WA

The Design and Testing of Lithium Hydroxide Shielded Cask for Transportation of Fast Neutron Emitting Heat Sources
R. D. Seagren, Union Carbide Corporation, Oak Ridge National Laboratory, Oak Ridge, TN

A light-weight package for storage and transport of 250 watt curium oxide heat sources.

Transportation Safety of Trans-Plutonium Actinides
C. M. Copenhaver, Oak Ridge Operations Office, USAEC, Oak Ridge, TN

Shielded Neutron Shipping Cask

C. L. Hanson and M. S. Coops, Lawrence Radiation Laboratory, Livermore, CA and E. D. Arnold, Oak Ridge National Laboratory, Union Carbide Corporation, Oak Ridge, TN

A cask designed for the shipment of californium 252 is described.

Recent Developments in Nondestructive Evaluation Applicable to Encapsulated Isotopes

D. R. Newman and J. C. Crowe, Battelle—Pacific Northwest Laboratories, Richland, WA

Recent developments in the use of ultrasonics as a nondestructive test procedure are described.

8:30 AM **SESSION 4B. ACCIDENT EXPERIENCE**

Federal Building Auditorium

Chairman: C. A. Mayer, Tri State Motor Transit Co., Joplin, MO

The AEC Accident Record and Recent Changes in AEC Manual Chapter 0529

W. C. McCluggage, Division of Operational Safety, USAEC, Washington, D.C.

Development of rules and regulations for the safe transport of radioactive materials is traced from the pre-nuclear period to present time. Accident experience is reviewed. Changes in existing regulations designed to provide clearer understanding are discussed.

Highway Accident Involving Cold Uranium Scrap

D. F. Cronin, Naval Products Division, United Nuclear Corporation, New Haven, CT

This paper describes a one-vehicle accident in which the cargo was highly enriched scrap material.

Enrichment Errors in Interplant Shipment

D. L. Dunaway, National Lead Company of Ohio, Fernald, OH

The potential for error in handling enriched materials and case histories is described.

Shipping Incidents (Gee! It Wasn't That Way When I Closed the Top)

R. C. Becker, Lawrence Radiation Laboratory, Livermore, CA

Two incidents involving the shipment of radioactive materials are described with causes and corrective steps taken for avoidance in future.

10:00 AM Intermission

10:30 AM **SESSION 5A. Isotope and Waste Packaging Technology (Part II)**

Hanford House Convention Center

Chairman: D. R. Smith, University of California, Los Alamos Scientific Laboratory, Los Alamos, NM

Shielded Transport Containers for Intermediate and High Level Radioactive Wastes

W. Bechthold and J. J. Heil, Karlsruhe Nuclear Research Center, Karlsruhe, Germany

Transport containers developed for material shipment to ASSE salt mine are described.

"Celotex" Insulated Shipping Containers

E. E. Lewallen, E. I. du Pont de Nemours Company, Savannah River Plant, Aiken, SC

"Celotex" insulating material for thermal and shock protection in shipping containers is discussed.

Economics, Compositions and Process Equipment for Radioactive Waste Solidification

L. Rutland, ATCOR, Inc., Elmsford, NY

A solidification process based on a cement-waste material mix is presented.

New Facility for Packaging Radioactive Liquid Wastes

D. E. Bloomfield, Gilbert Associates, Inc., Reading, PA

The author presents a process for the solidification and packaging of liquid wastes.

Design of Low Cost Fire Shields for Small and Large Radioisotope Shipping Containers

R. A. Harrod and J. D. W. de Lind van Wijngaarden, Atomic Energy of Canada, Ltd., Ottawa, Ontario, Canada

Discusses a design for shipping containers utilizing wood as the insulating medium. Fire and drop test results are presented.

10:30 AM **SESSION 5B: Shipment of UF_6**

Federal Building Auditorium

Chairman: C. W. Walter, Nuclear Division, Union Carbide Corporation, Paducah, KY

Enriching Services Transportation

B. M. Robinson, Production Division, Oak Ridge Operations Office, USAEC, Oak Ridge, TN

An examination is made of the statistics of UF_6 shipments since the initiation of leasing and toll enrichment services with considerations of future transportation requirements in view of anticipated growth of the nuclear power industry.

Nuclear and Radiological Safety Aspects in Transporting Uranium Hexafluoride

W. A. Johnson, Safety and Environmental Control Division, USAEC, Oak Ridge, TN and C. E. Newlon and R. G. Taylor, Nuclear Division, Union Carbide Corporation, Oak Ridge, TN

The safety parameters affecting design and shipment of UF_6 containers is examined in context of package dimension, materials of construction, enrichment, moderation, reflection and package arrays.

Engineering and Quality Control Considerations in the Safe and Economical Handling of Uranium Hexafluoride Cylinders

J. W. Arendt, Nuclear Division, Union Carbide Corporation, Oak Ridge, TN

A summary of the operational and transportation experience with UF_6 cylinders is presented. Development of an industry standard is described.

Economics of Transportation - Uranium Hexafluoride

J. A. Lamb, Supply Division, Oak Ridge Operations Office, USAEC, Oak Ridge, TN: G. B. Brooks, Nuclear Division, Union Carbide Corporation, Oak Ridge, TN; A. T. Freeman, Nuclear Division, Union Carbide Corporation, Paducah, KY; and W. R. Simpson, Goodyear Atomic Corporation, Piketon, OH

With the inception of the toll enrichment program, larger and larger quantities of UF_6 are moving in interstate commerce. The economic factors affecting transportation costs, service to customers, packaging, regulations, etc., are examined.

12:00 Noon Lunch

1:30 PM **SESSION 6A. Spent Fuel — Experience and Problems (Part I)**

Hanford House Convention Center

Chairman: R. W. Peterson, Allied-Gulf Nuclear Services, Barnwell, SC

Indian Experience in Transportation of Irradiated Fuel

N. Srinivasan, et al., Bhabha Atomic Research Centre, Trombay, Bombay, India

Details of transport of irradiated fuels to reprocessing plant by truck and rail are given. Types of flasks, design criteria and safety analyses are discussed.

Experience in the Transportation of the Radioactive Materials in Italy

A. Calori, C. Faloci, V. Lanzillo, and A. Susanna, Comitato Nazionale per L'Energia Nucleare, Rome, Italy

The terrain of Italy, with many tunnels, viaducts, bridges and mountain highways, necessitates very close attention to the safety analysis of transport methods.

Practical Experience in Spent Fuel Shipping Related Cask Concepts

P. Blum, H. Baatz and J. Mangusi, Transnuclear, Inc., New York, NY

A large number of shipments of spent fuel from 35 reactors to 9 processing plants have given the Transnuclear Group unprecedented experience in this field, but not without encountering problems. This paper describes some of these problems and indicates some safe and economical solutions with relation to cask concepts.

1:30 PM **SESSION 6B. Isotope and Waste Packaging Technology (Part III)**

Federal Building Auditorium

Chairman: H. A. Nowak, Associate Director, Division of Waste Management and Transportation, USAEC, Washington, D.C.

Safety in Salt (Film)

Also to be shown Wednesday, August 18, 12:45 PM, Federal Building Auditorium

Introduction by J. A. Sisler, Division of Waste Management and Transportation, USAEC, Washington, D.C.

Covers general background information on the establishment of the Lyons, Kansas, salt mine repository, and how it will operate. Waste solidification processes are described briefly. Current transport systems and inherent safety features are viewed in detail.

Transportation Systems for Salt Mine Waste Repository

W. A. Brobst, Division of Waste Management and Transportation, USAEC, Washington, D. C.

A new demonstration federal radioactive waste repository is being established in a salt mine at Lyons, Kansas. This paper is a progress report on the development of a safe transportation system, including package acceptance criteria, that will assure smooth operations at the mine and encourage public acceptance of the repository concept.

ATMX 500 Railcar as a Radioactive Waste Package

E. P. McDonald, Mound Laboratory, Monsanto Research Corporation, Miamisburg, OH

Development and licensing of the ATMX 500 series railcar is described.

ATMX 600 Railcar — A New Concept in Radioactive Waste Shipments

F. E. Adcock, Rocky Flats Division, The Dow Chemical Company, Golden, CO

Development and licensing of the ATMX-600 series cars is discussed.

3:00 PM Intermission

3:15 PM

SESSION 7A. Spent Fuel Experience and Problems (Part II)

Hanford House Convention Center

Chairman: E.C. Lusk, Battelle—Columbus Laboratories, Columbus, OH

Spent Fuel Transportation State-of-the-Art

R. W. Peterson, Allied-Gulf Nuclear Services, Barnwell, SC

Spent fuel transportation is reviewed from the viewpoint of a major fuel recovery plant operator. Problems in packaging design, licensing, transportation and public acceptance are covered.

Effect of Highway Weight Limits on Cost of Spent Fuel Shipments

K. H. Dufrane, Nuclear Fuel Services, Inc., Wheaton, MD

The significance of cask size and weight in relation to payload and effect on transport costs is discussed.

Radioactive Transportation Activities for a Fuels Reprocessing Plant

D. D. Wodrich, Nuclear Diversification Division, Atlantic Richfield Hanford Company, Richland, WA

Transportation activities associated with a six-tonne per day reprocessing plant, stated on annual basis of 1600 tonnes per year are described.

Mass into Energy (Westinghouse Film)
Introduction by H. E. Walchli, Nuclear Division, Westinghouse Electric Corporation, Pittsburgh, PA

Requirements for the Development of Shipping Casks for Use with Power Reactor Fuel
H. E. Walchli

Discusses the items to be considered in the development of a typical shipping cask.

3:30 PM **SESSION 7B. Isotope and Waste Packaging Technology (Part IV)**
Federal Building Auditorium

Chairman: J. F. Brown, Chief of Operations, Radioactive Materials Packaging & Transportation, National Lead Company, Wilmington, DE

Operating Experience in Shipment of Radioactive Material
V. K. Iya, R. G. Deshpande and M. D. Kulkarni, Isotope Division, Bhabha Atomic Research Centre, Trombay, Bombay, India

During the past twelve years the Isotope Division of Bhabha Atomic Research Centre has made over 100,000 consignments of various radioisotopes. Experience and packaging designs are described.

Development, Design and Construction of a Shipping Container for Tritiated Heavy Water
C. G. Cameron and R. H. Smith, Atomic Energy of Canada, Ltd., Whitesehell Nuclear Research Establishment, Pinawa, Manitoba, Canada

Shipment of heavy water contaminated with tritium in approved containers, design and test evaluation is discussed.

Processing and Packaging of Solid Wastes from BWR's
H. L. Loy and D. C. Saxena, Atomic Power Equipment Department, General Electric Company, San Jose, CA

The disposal of solid wastes generated in the operation of large boiling water reactors is described.

Design Considerations for High Volume IAEA Type B Protective Overpack Shipping Containers in Use with Current Transportation Systems
K. Gablin, Protective Packaging, Inc., Tacoma, WA

Design and testing of overpack systems.

6:00 - 7:00 PM

Social Hour
Rivershore Motor Inn
(Host: WADCO Corporation)

7:00 PM

Banquet
Rivershore Motor Inn
(Host: Symposium Committee)

Guest Speaker: Dr. Edward Lindaman
President of Whitworth College
Spokane, WA

Wednesday, August 18

8:30 AM

SESSION 8A. Insurance and Radiation Safety
Hanford House Convention Center

Chairman: Hudson B. Ragan, Assistant General Counsel for Operations, USAEC, Washington, D.C.

Insurance and Indemnity Protection for Nuclear Materials in Transportation
J. D. Saltzman and C. J. Holloway, Indemnity and Export Control Branch, Division of State and Licensee Relations, USAEC, Washington, D.C.

Price-Anderson Act extensions, indemnified coverage and extension of coverage for U.S. flag vessels in sea transport are presented.

Third Party Liability Insurance and Government Indemnity Associated with the Transportation of Radioactive Materials
L. G. Cummings, Nuclear Department, Marsh & McLennan, Incorporated, New York, NY

Types of insurance coverage, inadequacies and limitations relating to radioactive materials shipment are discussed.

Processing of Radioactive Shipments from the Standpoint of Radiation Safety

C. W. Buckland, University of California, Los Alamos Scientific Laboratory, Los Alamos, NM

Procedures used by the LASL Health Physics group in connection with radioactive shipments, preplanning and preparation of data sheets are described.

Radiation Survey of the Transportation of Radioactive Materials

G. D. Schmidt, Bureau of Radiological Health, U.S. Public Health Service, Rockville, MD

Radioactive materials shipments are surveyed for degree of compliance with applicable regulations.

Method of Controlling Radiation Exposure of Persons in Aircraft During Transport of Radioactive Materials

P. A. Lecomte, Engineering Department, Sabena Belgian World Airlines, Brussels, Belgium

Stowage of radioactive cargo to minimize exposure of passengers and crew to penetrating radiation is described.

8:30 AM **SESSION 8B. Spent Fuel Packaging Technology (Part I)**

Federal Building Auditorium

Chairman: H. P. Shaw, Manager, Manufacturing Department, Atlantic Richfield Hanford Company, Richland, WA

Analysis of Packaging Compliance to Transport Regulations

H. Lucas and M. Labrousse, Commissariat L'Energie Atomique, Fontenay-Aux-Roses, France

Mathematical analysis of packaging concepts and physical testing of components and scale models are presented.

Review of Experimental Studies on the Fissile Fuel Shipping Cask in Japan
S. Aoki, Tokyo Institute of Technology, Tokyo, Japan

Experimental investigations in support of spent fuel shipping cask design are discussed; includes heat removal test, over-the-road test, drop test, and analysis of data.

Evaluation of Metal Seal Criteria for Spent Fuel Cask Closures
R. E. Latham and R. T. Brown, Engineering Division, Gray Tool Company, Houston, TX

Seal parameters for metal-to-metal joints to minimize leakage are discussed. Loading and reuse of seals and economic factors are considered.

"**First Class Return**" (Film)
Also to be shown Thursday, August 19, 12:45 PM in the Federal Building Auditorium
J. Smith and S. Williamson, British Nuclear Fuels, Ltd., Risley, Warrington, England

Transportation of irradiated fuel destined for reprocessing at Windscale is pictured.

10:00 AM Intermission

10:30 AM **SESSION 9. Workshop on Transportation Regulations**

Hanford House Convention Center

Introduction: C. F. Goodner, Chief (Ret.),
Traffic Management,
USAEC, Richland Operations Office
Richland, WA

Panel Moderator

Dr. Robert A. Kaye
Bureau of Motor Carrier Safety
Department of Transportation
Washington, D.C.

Panel Members

Robert F. Barker
Division of Radiation & Environmental Protection
USEAC, Washington, D.C.

Robert W. Blackburn
Atomic Energy Control Board
Canada

William A. Brobst
Chief of Transportation
USAEC, Washington, D.C.

Alfred W. Grella
Office of Hazardous Materials
U.S. Dept. of Transportation
Washington, D.C.

Donald W. Nussbaumer
Division of Materials Licensing
USAEC, Washington, D.C.

Wade C. McCluggage
Division of Operational Safety
USAEC, Washington, D.C.

Wednesday, August 18
Afternoon

(Open for Tours)

Evening

(No events scheduled)

Thursday, August 19

8:30 AM **SESSION 10A. Spent Fuel Packaging Technology (Part II)**

Hanford House Convention Center

Chairman: R. Blomquist, Aktiebolaget Atomenergj, Studsvik, Sweden

Recent Developments in Lead Shields for Transport Containers in UK

R. Smith, Lead Development Association, London, England

Design practices for the fabrication of lead shields are traced from initial use to the present time and the need for change over the years is examined.

Shielding Aspects of LWR Spent-Fuel Shipping Casks

B. A. Engholm, Gulf General Atomic, San Diego, CA

Studies of single and multi-element cask design; neutron and gamma shielding are described and compared with recent cask designs.

Lead Remelt Experience with 60-Ton Cask

E. C. Lusk, Battelle Memorial Institute, Columbus Laboratoreis, Columbus, OH

Data obtained during a lead shielding remelt of a large cask was used to evaluate cask thermal response.

Impact Testing of Chemical Lead, Cask Models, and an Energy Absorbing Device

J. H. Evans, Union Carbide Corporation, Oak Ridge National Laboratory, Oak Ridge, TN

Free fall impact testing programs are described; scale model casks were used and an energy absorbing device was tested.

8:30 AM **SESSION 10B. Administrative Experience**
Federal Building Auditorium

Chairman: P. A. Lecomte, Engineering Department, Sabena Belgian World Airlines, Brussels, Belgium

Administration of the Radioactive Materials Transportation Safety Program
W. A. Pryor, Oak Ridge Operations Office, USAEC, Oak Ridge, TN

Operation of Oak Ridge shipping activities is described. Experience is recounted and shipping incident reviewed.

Responsibilities of Consignor and Consignee
K. R. Schendel, Westinghouse Electric Corporation, Pittsburgh, PA

Development of Documentation for the Transport of Radioactive Materials
J. Fairey, Atomic Weapons Research Establishment, United Kingdom Atomic Energy Authority, Aldermaston, England

Documentation required for movement of fissile and radioactive materials is described.

Expeditious Handling and Followup of Medical Isotopes Delivery
S. H. Sanger, Cabs Unlimited, Mountain View, CA

The mechanics of a delivery system for medical and research radioisotopes is described.

10:00 AM Intermission

10:30 AM

SESSION 11A. Spent Fuel Packaging Technology (Part III)

Hanford House Convention Center

Chairman: W. A. McVey, Division of Reactor Development and Technology, USAEC, Washington, D.C.

An Experimental Study on the Drop Impact of Spent Fuel Shipping Cask

S. Aoki, Y. Kanae, A. Muramatu, S. Nakata, H. Nakazawa, and S. Shimamura, Japan Society of Mechanical Engineers, Tokyo, Japan

Drop impact tests for scale model casks (10,5 and 1.25t) are described; includes film presentation.

Impact Testing of Cask Fin Specimens

F. C. Davis, Oak Ridge National Laboratory, Oak Ridge, TN

Typical fin geometries are impact tested and data obtained and analyzed to determine energy absorption characteristics.

Impact Test of Models at the Savannah River Plant

J. W. Langhaar, E. I. du Pont de Nemours Company, Atomic Energy Division, Wilmington, DE

Testing of small scale models for assessing cask characteristics and design parameters are described.

Correlations for Cask Drop Tests

K. Lee, ATCOR, Inc., Elmsford, NY

10:30 AM

SESSION 11B. Nuclear Safety

Federal Building Auditorium

Chairman: R. L. Stevenson, Division of Materials Licensing, USAEC, Washington, D.C.

Methods Used to Calculate Package Criticality Safety

W. T. Mee, Nuclear Division, Union Carbide Corporation, Oak Ridge, TN

Application of Fissile Material Storage Limits to Criticality Safety Analysis in Transport

J. T. Thomas, Union Carbide Corporation, Oak Ridge, TN

Development of spherical mass limits in water reflected storage arrays for specification containers is discussed.

Criticality Safety Evaluations of Shipping Containers Used by Idaho Nuclear Corporation at NRTS

J. K. Fox and W. G. Morrison, Idaho Nuclear Corporation, Idaho Falls, ID

Calculation techniques used for criticality evaluation of shipping systems are presented.

ATMX Railcar — Nuclear Safety Evaluation

J. D. McCarthy, Rocky Flats Division, The Dow Chemical Company, Golden, CO

Criticality Analysis for the ATMX 600 series railcar loadings is shown.

12:00 Noon Lunch

1:30 PM **SESSION 12A. Spent Fuel Packaging Technology (Part IV)**

Hanford House Convention Center

Chairman: S. T. Daughtrey, Atomic Energy Control Board, Ottawa, Ontario, Canada

Study of Fire Resistivity for Irradiated Fuel Shipping Cask

T. Moriya and H. Shimada, Fire Research Institute Japan, Tokyo, Japan

Model spent fuel casks were subjected to temperatures to 800° C. Data analysis is examined.

A Thermal Test Evaluation Method for Lead and Uranium Shielded Casks

J. C. Glynn, Division of Reactor Licensing, USAEC, Washington, D.C. and R. H. Odegaarden, Division of Materials Licensing, USAEC, Washington, D.C.

A programmed evaluation of performance of lead and uranium shielded casks over a wide range of conditions is discussed.

Shipping Container Design for Heat Removal

A. Serkiz and E. C. Lusk, Battelle Memorial Institute, Columbus Laboratories, Columbus, OH

1:30 PM **SESSION 12B. Non-Irradiated Fuel Packaging Technology**

Federal Building Auditorium

Chairman: R. W. Blackburn, Atomic Energy Control Board, Ottawa, Ontario, Canada

Evaluation of Plutonium Product Form on Safety During Transportation

L. M. Knights, Chemical Processing Division, Atlantic Richfield Hanford Company, Richland, WA

Effect of Pu Nitrate Shipping on the Reactor Fuel Fabricator

T. P. Bullock, Nuclear Fuel Division, Westinghouse Electric Corporation, Cheswick, PA

The fuel fabricator should have the option of receiving plutonium in a form compatible with his manufacturing process.

Drop Tests of Shipping Containers for PWR Type New Fuels

Y. Seki, S. Aoki, S. Nakata, S. Shimamura, Y. Kanae, and T. Koguchi, Mitsubishi Atomic Power Industries, Inc., Japan Society of Mechanical Engineers, Tokyo, Japan

Dynamic analysis of a system under test condition is presented.

A Shipping Container for Unirradiated Power Reactor Components

R. E. Kropp, Commercial Products Division, Gulf-United Nuclear Corporation, New Haven, CT

Design bases, safety analyses and evaluations of a shipping container for BWR and PWR fuel elements are presented.

A Simple Shipping System for Power Grade Plutonium Oxide

R. E. Giebel and R. G. Leebl, Rocky Flats Division, The Dow Chemical Company, Golden, CO

A shipping system using DOT Specification 6M containers for PuO_2 is described.

3:00 PM Intermission

3:30 PM

SESSION 13A. Spent Fuel Packaging Technology (Part V)

Hanford House Convention Center

Chairman: D. A. Nussbaumer, Division of Materials Licensing, USAEC, Washington, D.C.

Compact Metallic Impact Limiters and Fire Protectors for Shipping Containers

R. J. Burian and E. C. Lusk, Battelle Memorial Institute, Columbus Laboratories, Columbus, OH

Development of impact limiter designs is discussed.

Dynamic Environment Experienced During Normal Rail and Truck Transport

J. T. Foley and M. B. Gens, Sandia Laboratories, Albuquerque, NM

Instrumented transport of a shipping cask by truck and rail is described in terms of the shock and vibration environment encountered.

Thursday, August 19 (contd)

Upgrading of PM-3A Casks
R. A. Scaggs, E. I. du Pont de Nemours and Company, Savannah River Plant, Aiken, SC

Pm-3A casks are used for shipment of fuels from Antartica to the U.S. Necessary modification based upon service history are described.

3:30 PM **SESSION 13B. Needs and Progress in Standardization**
Federal Building Auditorium

Chairman: L. B. Shappert, Nuclear Division, Union Carbide Corporation, Oak Ridge, TN

American Nuclear Standards Institute Committee N14 — Transportation of Fissile and Radioactive Materials (Progress Report)
J. W. Langhaar, E. I. du Pont de Nemours and Company, Atomic Energy Division, Wilmington, DE

Status of Specification Container Concept
J. A. Sisler, Division of Waste Management & Transportation USAEC, Washington, D.C.

Future Trends in Automated Freight Handling Systems
J. R. Davis, Drake Sheahan/Stewart Dougall, Inc., New York, NY

Quality Control of Shipping Cask Fabrication
A. Short, Hanford Engineering Services Division, Vitro Corporation, Richland, WA

Safety standards and quality control in modification of a large Hanford cask for cesium shipments.

6:00 PM **Social Hour**
(Host: Battelle—Pacific Northwest Laboratories

7:00 PM **Buffet Dinner**
(Host: Douglas-United Nuclear)

Thursday, August 19 (contd)

8:00 PM

SESSION 14

Introduction: D. A. Hoover, Consulting Engineer
Atlantic Richfield Hanford Company,
Richland, WA

Panel: "The Hijacking and Pilferage Problem"

Panel Moderator

Mr. William A. Brobst
Chief of Transportation
U.S. Atomic Energy Commission
Washington, D.C.

Panel Members

Mr. Robert G. Begeman
Transport Insurance Company
4100 Harry Hines Blvd.
Dallas, Texas

Mr. Samuel Edlow
Edlow International Company
1100 17th Street, N.W.
Washington, D.C.

Mr. James Fernan
American Trucking Assn.
1616 P Street, N.W.
Washington, D.C.

Mr. Harry J. Murphy
Air Transport Assn. of America
1000 Connecticut Ave., N.W.
Washington, D.C.

Mr. Chester H. Smith
Select Senate Committee
on Small Business
United States Senate
Washington, D.C.

Mr. Daniel A. Ward
Acting Deputy Director
Office of Transportation Security
U.S. Dept. of Transportation
Washington, D.C.

Panel Topics

- General hijacking and pilferage problems in terms of freight (packages) and transport vehicles containing freight; includes freight carrying aircraft.
- Hijacking or diversion of material subject to USAEC safeguards
- Hijacking or pilferage problems involving the theft or diversion of other radioactive material (not subject to safeguards) for black-market sale or use for sabotage and civil disturbance activities.

Friday, August 20
Hanford House Convention Center

8:30 AM **SESSION I5. New Spent Fuel Cask Designs**

Chairman: D. R. Swindle, Division of Contracts, USAEC
Washington, D.C.

HTGR Spent Fuel Shipping Casks
C. R. Davis, Gulf General Atomic, San Diego, CA

Evaluation of cask designs for truck and rail transport of high temperature gas-cooled reactor fuel elements is presented.

Shipping Casks for Spent Fuel With High Burnup
F. Schmiedel and R. Dietrich, Krupp Maschinenfabriken, Essen, West Germany

Shielding and heat transmission parameters are investigated. Wall thickness, weight, and temperature distribution factors are discussed for different cask sizes.

General Description of Expected Size and Capability of 1100 MWe Reactor Spent Fuel Shipping Casks for Highway Use
J. P. Malone, ATCOR, Inc., Elmsford, NY

Design parameters of large casks for BWR fuel transport are described.

IF-300 Spent Fuel Shipping Cask
C. W. Smith and R. H. Jones, General Electric Company, San Jose, CA

Design experiences are discussed.

10:00 AM Intermission

Friday, August 10 (contd)

10 30 AM **SESSION 16. Advanced Technology**
Hanford House Convention Center

Chairman J W Langhaar, E I du Pont de Nemours and and Company, Atomic Energy Division, Wilmington, DE

Contribution to the Design of Type B Packages for High Residual Power Irradiated Fuel Elements
H Bruel and C Bochard, Robatel SLPI, 69 Genas, France

New materials and designs for the manufacturing of packages for LWR fuels are presented

An LMFBR Fuel Shipping Cask Concept and Observations Pertaining to Hazard Survival Potential
L B Shappert and A R Irvine, Oak Ridge National Laboratory, Oak Ridge, TN

Air Cushion Support for Highway Transport of Heavy Loads
W H Trask, Riggers Manufacturing Co , Kennewick, WA

Application of air cushion technology to transport of heavy loads (heavily shielded casks) is examined Technology and economics are explored

Use of Computer Movies for Mechanical Test Simulation
B J Donham, Los Alamos Scientific Laboratory, Los Alamos, NM

Techniques used for solution of problems of heat transfer and impact are described

An Economic and Engineering Analysis of a Unit Train Concept for the Transport of Spent Fuel Assemblies from Commercial Nuclear Power Plants
Arthur G Trudeau North American Rockwell, Washington, D C and Darrow E Haagensen Energy Consultants Inc Chevy Chase MD

Unit train concept and a cask design are discussed

12 00 **End of Symposium**

Sessions Aides

Coordinator: Carl Zangar, Vitro Engineering

A — Hanford House Convention Center
B — Federal Building Auditorium

Monday — August 16

Dave Prezbindowski — BNW
Session 1 — 10:00-12:00 AM

Norm Wittenborck — BNW
Session 2 — 1:30-3:00 PM
Session 3 — 3:00 PM

Tuesday — August 17

Frank Zelley—BNW
Session 4A — 8:30 AM
Session 5A — 10:30 AM

Bob Anderson — ARHCO
Session 4B — 8:30 AM
Session 5B — 10:30 AM

Jim Houston — ARHCO
Session 6A — 1:30 PM
Session 7A — 3:30 PM

Eric Oscarson — ARHCO
Session 6B — 1:30 PM
Session 7B — 3:30 PM

Wednesday — August 18

Jack Kleinpeter — Vitro
Session 8A — 8:30 AM
Session 9 — 10:30 AM

Murray Rutherford — Vitro
Session 8B — 8:30 AM

Thursday — August 19

John Meyers — DUN
Session 10A — 8:30 AM
Session 11A — 10:30 AM

Fred Williams — AEC
Session 10B — 8:30 AM
Session 11B — 10:30 AM

Morton Carrothers — AEC
Session 12A — 1:30 PM
Session 13A — 3:30 PM

Dave Templeton — AEC
Session 12B — 1:30 PM
Session 13B — 3:30 PM

Neal E. Carter — BNW
Session 14 — 8:00 PM

Friday — August 20

Ken Heid — BNW
Session 15 — 6:30 AM
Session 16 — 10:30 AM

Alternates:
Murray Rutherford — Vitro
Carl Zangar — Vitro

SYNOPSIS OF PROGRAM

Monday, August 16	Tuesday, August 17	Wednesday, August 18	Thursday, August 19	Friday, August 20
9 30 Opening of Symposium (HH) 10 45 Intermission 11 15 1—Transportation Perspective (HH)	8 30 4A—Isotopes/ Waste I (HH) 4B—Accidents (FB) 10 00 Intermission 10 30 5A—Isotopes/ Waste II (HH) 5B—UF_6 (FB)	8 30 8A—Insurance/ Radiation Safe (HH) 8B—Spent Fuel Tech I (FB) 10 00 Intermission 10 30 9—Regulations Workshop (HH)	8 30 10A—Spent Fuel Tech II (HH) 10B—Administration (FB) 10 00 Intermission 10 30 11A—Spent Fuel Tech III (HH) 11B—Nuclear Safety (FB)	8 30 15—New Cask Designs (HH) 10 00 Intermission 10 30 16—Advanced Technology (HH)
12 00 Lunch	12 00 Lunch	12 00 Lunch	12 00 Lunch	12 00 Lunch
	12 45 Ecology Movie—FB	12 45 Salt Mine Movie—FB	12 45 UK Cask Movie—FB	12 45 Ecology Movie—FB
1 30 2—U S Regulations (HH) 3 00 Intermission 3 30 3—International Regulations (HH)	1 30 6A—Spent Fuel Experience I (HH) 6B—Isotopes/ Waste III (FB) 3 00 Intermission 3 30 7A—Spent Fuel Experience II (HH) 7B—Isotopes/ Waste IV (FB)	**TOURS**	1 30 12A—Spent Fuel Tech IV (HH) 12B—New Fuel/ Pu (FB) 3 00 Intermission 3 30 13A—Spent Fuel Tech V (HH) 13B—Standards (FB)	**END OF SYMPOSIUM**
6 00-8 00—Reception (HH)	6 00 Social Hour (RS) 7 00 Banquet (RS)	**No Scheduled Events**	6 00 Social Hour (HH) 7 00 Smorgasbord (HH) 8 00 14—Hijack Panel (HH)	**NOTATIONS:** HH — Hanford House FB — Federal Building RS — Rivershore

SYMPOSIUM SUMMARY

The Third International Symposium on Packaging and Transportation of Radioactive Materials was held at Richland, Washington, August 16-20, 1971. The following report of the Symposium is supplied to NUCLEAR NEWS by Aubrey O. Dodd, Richland Operations - USAEC.

As the above title indicates, this was the third meeting on an international scale of a growing fraternity of specialists whose duties and interests involve the packaging and safe transport of radioactive materials. Growing out of the first formal gathering in this country by representatives of the nuclear industry concerned with packaging and transportation standards, at Germantown-AEC in 1962, the first international forum was at Albuquerque (Sandia) in 1965, and the second at Gatlinburg (Union Carbide) in 1968. Assisting the USAEC in sponsoring this third international gathering were the six major contractors at the AEC Hanford Project: Atlantic Richfield Hanford Company; Battelle-Northwest; Douglas United Nuclear, Inc.; ITT/Federal Support Services, Inc.; J. A. Jones Construction Company; Vitro Engineering; WADCO Corporation. The high quality of the arrangements and functioning of the week-long workshop reflected the interest and support of all these organizations. Over 450 registrants attended part or all of the sessions, and visitors from 16 countries were counted.

While the keynote address by Gen. Benjamin O. Davis, USAF (Ret.), Assistant Secretary for Safety and Consumer Affairs, U.S. Department of Transportation, pointed up the Government's concern for radioactive materials transport safeguards because of possible theft of nuclear weapon materials and possible contamination incidents due to malicious mischief, the principal thrust of the symposium agenda centered around design of shipping systems for shielding and containment of coming high burn up, high decay heat spent nuclear fuels. E. B. Tremmel, Director, Division of Industrial Participation, USAEC, Washington, noted in his lead paper that systems planning for nuclear transportation has lagged because of significant delays in nuclear plants coming on line. He also predicted that fuel reprocessors would become purchasers of the larger casks to serve the spent fuels transportation needs, and that much of the volume of such transport would be provided by specialized carriers (rather than common carriers). He also foresaw something like a 50-50 sharing of the transport business between rail and highway carriers, assuming that efficient cask designs are developed so that highway load limits are not exceeded.

Recapping the agenda statistics, there were 18 papers dealing with spent fuel packaging technology, 17 papers on isotopes and waste packaging technology, eight on spent fuel experience and problems, and four on new spent fuel cask designs; there were 10 papers discussing radioactive materials packaging and shipping regulations (U.S. and international), five dealing with insurance and radiation safety in transport, four on needs and progress in standardization; four papers discussed the shipment of UF_6, five on non-irradiated fuel packaging technology, five on advanced technology in cask design and testing; four papers dealt with nuclear criticality safety; four papers covered transport accident experience; and four papers considered administrative experience with radioactive shipments. In all, there were 93 papers presented, plus the keynote address and two workshop or panel discussions. These were handled, during the three full days and two half days of sessions, with simultaneous sessions at the Hanford House (Symposium Center) and at the Federal Building auditorium nearby. Exhibits of shipping containers, including those for unirradiated fissile materials, neutron shielding and spacing, low- to high-level wastes, unitized cargo container overpack for large volume shipments, and a specialized carrier's tractor-trailer with communications capability were on display during the Symposium.

Two papers on regulations governing packaging and transport of radioactive materials presented a consensus that technical standards currently are adequate to assure public safety, but that administrative controls are under review with regard to approaching a virtual zero risk situation as to possible theft and/or malicious acts. J. A. Sisler, USAEC Division of Transportation, raised several questions regarding how well the current regulatory container testing procedures represent the transport environment, and challenged the industry to avoid the complacency of unquestioning acceptance of the test standards as if they were immutable. A. W. Grella, Office of Hazardous Materials, U.S. Department of Transportation, observed that "In regard to radioactive materials standards, we feel that the provisions in the DOT regulations for these materials are much more technically advanced in their 'state of the art' than for any other hazardous commodity." Wade McCluggage, USAEC Division of Operational Safety, in summarizing the statistics of AEC's approximately 25 years of radioactive materials shipping, noted that there has never been a transport accident in which a Type B package (one which contains a quantity large enough to adversely affect the environment) was breached and its contents released. Gen. Davis in his keynote address had noted that fact by stating that NASA and AEC are the only two agencies with perfect transportation records to date, and urged that the public be made more aware of the nuclear industry's outstanding safety record.

In the subject area of isotope and waste packaging technology, there were papers dealing with neutron shielding materials and container development and testing. There were papers describing waste solidification and packaging for transport and disposal. There was a report on an extensive testing program for fire shielding protection of transport containers; also papers dealing with packaging and transport systems for ultimate storage of radioactive wastes in salt domes, modification of rail cars to serve as transport packages for high specific activity alpha-emitter wastes, and a paper on the application of ultrasonics to nondestructive evaluation of container integrity. One paper proposed adding selected odd neutron actinides to the fissile list and suggested establishing a fast fissile nuclide category in the transport regulations. A packaging designer/fabricator discussed a high volume IAEA Type B and large quantity protective overpack, in the form of a standard 8'x8'x20' cargo container.

The Symposium session on accident experience appeared hard-pressed to find sufficient information to warrant papers. However, there were reported a few cases of packaging errors which, while not resulting in release of radioactive materials, yet signaled a warning for areas of packaging design and operator procedure. One paper pointed up the complications of getting medical care for an injured driver whose vehicle carrying radioactive material had experienced an accident but with no release of contents.

Because of the large tonnage currently in transport, several papers dealt with UF_6, looking at such aspects as nuclear criticality safety, container design and standardization, radiological safety of transuranic nuclides in UF_6, and transportation economics. With a projected transportation cost to the nuclear industry of above 20 mega dollars in this current decade for UF_6 alone, the search for economies will be an ever present incentive.

The Session on insurance included definitive and informative papers on the unique arrangements for indemnity and liability coverage to nuclear facilities. It was noted that since 1957, the nuclear liability loss experience for commercial operations has totaled nine reported claims involving transportation, five of which concerned contamination of property, with an average loss payment of about $1,700. The overall industry experience to date has been exceptionally good, resulting in domestic nuclear liability insurance premium refunds of approximately 65 percent. Problem areas remain, however, with respect to optimizing shipment size-weight, contents, mode of transport, etc., as these factors relate to potential liability and hence insurance coverage.

The topical session dealing with administrative experience in radioactive materials transport produced detailed discussions of the many procedures required in planning, packaging, monitoring, labeling shipments, and the necessary audits to assure compliance with safety regulations. The step-by-step review by Carl Buckland of the procedures practiced at the Los Alamos Scientific Laboratory by the Health Physics Group does a lot to explain the excellent safety in transport record of the nuclear industry. An investigation of radioactive packages in transit was reported by Gail Schmidt of the USPHS. His studies indicated that the minimal radiation exposure to transportation workers was more to the credit of packager than to carrier compliance with subject regulations.

Sessions receiving principal attention during the Symposium dealt with spent fuel transport. Space does not permit detailing the many excellent papers concerned with physics and engineering aspects of container design, fabrication, testing, computerized test simulation, calculational evaluation, neutron and gamma shielding, heat transfer and auxiliary cooling systems, size and weight limitations, modes of transport, etc. Here one can only praise the Symposium Publications Committee who preprinted the papers as Proceedings of the Third International Symposium on Packaging and Transportation of Radioactive Materials. The Proceedings, a veritable library of information on every aspect of the subject, are available for purchase (three volumes - $15.00) from NATIONAL TECHNICAL INFORMATION SERVICE, U.S. Department of Commerce, Springfield, Virginia 22151.

In summary, for an observer's overview of this Symposium, the writer was favorably impressed by the quantity and quality of information brought together in a kind of status report of research, development and operating experience in the subject area. The Steering Committee (Duane Swindle, William Brobst and James Sisler, USAEC-HQ, and Larry Shappert, ORNL) are to be commended for their insight and skill in bringing together the varied sources of information affecting safety, technology and economics in the packaging and transport of radioactive materials. The contributions by representatives of countries abroad were exceptionally worthwhile. The indefatigable Frank Dixon from the UKAEA was genuinely missed, although his coworkers performed creditably. The interest and stimulus of the test demonstartions staged at the Albuquerque Symposium (1965) are still missing, but attendance and attention throughout the Richland meeting attest to the efforts and over-all success of the entire Symposium Committee and of each individual contributor.

VISITING ATTENDEES

THIRD INTERNATIONAL SYMPOSIUM

PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

August 16-20, 1971

Richland, Washington

THIRD INTERNATIONAL SYMPOSIUM

ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS

ATTENDEES

Name	Affiliation	Address	Motel
Abate, L. J.	General Electric - Knolls Atomic Power Lab.	Schenectady, New York	Rivershore
Adcock, Clifford J.	The Dow Chemical Co.	Boulder, Colorado	Rivershore
Anderson, Clifford J.	Nuclear Fuel Services	Buckeytown, Maryland	Rivershore
Aoki, Shigebumi	Tokyo Institute of Technology	Meguro, Tokyo, Japan	Hanford House
Arendt, J. W.	Union Carbide Corporation, Nuclear Division	Oak Ridge, Tennessee	Hanford House
Aupetit, Armand	Transnucleaire S.A.	75 Paris 8ème, France	Rivershore
Baatz, Henning (Dr.)	TRANSNUKLEAR GmbH Germany	New York, New York	Hanford House
Bader, B. E.	Sandia Laboratories,	Albuquerque, New Mexico	Rivershore
Blaes, James H.	USAEC	Idaho Falls, Idaho	Hanford House
Barker, R. F.	USAEC	Bethesda, Maryland	Hanford House
Barraclough, E. L.	AEC-AL	Albuquerque, New Mexico	Red Lion
Barton, Robert J.	Mason & Hanger Silas Mason Co., Inc.	Amarillo, Texas	Red Lion
Bashford, A. L.	General Electric Co.	Sunnyvale, California	Bali Hi
Bauman, T.	Nuclear Industry Magazine	Washington, D.C.	Hanford House
Bechthold, Werner	Gesellschaft für Vernforschung mbH	F501 Leopoldshaten, Germany	Hanford House
Becker, J. M.	USAEC	Washington, D.C.	Bali Hi
Becker, Robert C.	Lawrence Livermore Laboratory	Livermore, California	Hanford House
Begeman, R. G.	Transport Insurance Company	Dallas, Texas	Hanford House
Beierle, Fred. P.	Chem-Nuclear Services	Prosser, Washington	None
Berry, R. E.	Sandia Laboratories	Albuquerque, New Mexico	Red Lion

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Berteig, Leiv		13FO Asker, Norway	Hanford House
Bidinger, George	USAEC	Atlanta, Georgia	Hanford House
Bigge, W. B.	General Electric	San Jose, California	Hanford House
Blackburn, R. W. (Dr.)	Atomic Energy Control Board	Ottawa, Canada	Hanford House
Blechschmidt, Mr.	Physikalisch-Technische Bundesanstalt	Bundesallee 100 Fed. Republic of Germany	Hanford House
Bliss, H.	Commonwealth Edison	Chicago, Illinois	Hanford House
Blomquist, Roland	AB Atomenergi, Studsvik	Sweden	Hanford House
Bloomfield, D. E.	Gilbert Associates Inc.	Reading, Pennsylvania	Hanford House
Blum, Paul	Transnucleaire, S.A.	75 Paris 8ème, France	Hanford House
Blunden, D. J.	Nuclear Materials Services, Inc.	Detroit, Michigan	Red Lion
Boland, J. Robert	USAEC Nevada Oper. Office	Las Vegas, Nevada	Red Lion
Brewer, J. G.	E.L. duPont de Nemours	Hockessin, Delaware	Rivershore
Broadway, F. C.	Dow Chemical Co.	Denver, Colorado	Red Lion
Brobst, W. A.	USAEC, Wash,, D.C.	Riverdale, Maryland	Hanford House
Brown, J. F.	N. L. Industries, Inc.	Wilmington, Delaware	Hanford House
Brown, R. A. (Dr.)	Ontario Hydro	Toronto, Ontario, Canada	Red Lion
Bruce, E. I.	Sandia Laboratories	Albuquerque, New Mexico	Rivershore
Bruel, Henri	ROBATEL SLPI	GENAS (6g), France	Hanford House
Buckland, C. W., Jr.	Los Alamos Scientific Laboratory	Los Alamos, New Mexico	Hanford House
Bullock, T. P.	Westinghouse, FND	Pittsburg, Pennsylvania	Rivershore

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Burian, Richard J.	Battelle Col. Labs.	Columbus, Ohio	Hanford House
Burman, Carl L.	USAF,AFLC/DSP, Wright-Patterson AFB	Dayton, Ohio	Imperial
Burns, W. J.	Dept. of Transportation	Rockville, Maryland	Hanford House
Bush, F. J., Jr.	N. L. Industries, Inc.	Wilmington, Delaware	Rivershore
Byrom, J. P.	Aerojet Nuclear Co.	Idaho Falls, Idaho	Red Lion
Cairens, R. C. (Dr.)	Australian AEC	c/o Australian Embassy Washington, D.C.	Red Lion
Calori, Arturo	Comitato Nazionale per l'Energia Nucleare	Rome, Italy	Hanford House
Cameron, C. G.	Atomic Energy of Canada Ltd.	Manitoba, Canada	Hanford House
Carr, J. W.	Atomic Energy of Canada Ltd.	Chalk River, Ontario, Canada	Rivershore
Cecil, R. W.	Stearhs-Roger Corp.	Denver, Colorado	Red Lion
Chais, M.	USAEC, Transportation Branch	Washington, D.C.	Rivershore
Chandler, R. L.	USAEC, Savannah River Operations Office	Aiken, South Carolina	Rivershore
Chin, Steve	Lawrence Radiation Labs.	Livermore, California	Red Lion
Christensen, E. L.	Los Alamos Scientific Laboratory	Los Alamos, New Mexico	Rivershore
Conboy, J.	N. L. Industries, Inc.	Albany, New York	Rivershore
Cook, J. N.	USAEC	Albuquerque, New Mexico	Rivershore
Corless, J. R.	Ministry of Defense	Bath, Somerset England	Bali Hi
Cornish, A. C.	California Dept. of Public Health	Berkeley, California	Rivershore

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Cowan, W. S.	General Electric Co.	Belmont, California	Golden Door
Cox, J. K.	Union Carbide Corp. Nuclear Division	Tennessee	Rivershore
Crase, Arvil	Nuclear Eng. Co., Inc.	Sheffield, Illinois	Red Lion
Cronin, D. F.	United Nuclear Corp.	New Haven, Connecticut	Hanford House
Crooks, P. V.	Embassy of Australia	NW, Washington, D.C.	Rivershore
Cummings, L. G.	Marsh & McLennan, Inc.	Bellport, New York	Hanford House
Currie, D. A.	Canadian Nuclear Association and Eldorado Nuclear Ltd.	Port Hope, Ontario, Canada	Rivershore
Daniels, John	Dept. of Transportation	Washington, D.C.	Hanford House
Daughtrey, S. P.	Atomic Energy Control Board	Ottawa, Canada	Hanford House
Davis, Benjamin O.	Dept. of Transportation	Washington, D.C.	Hanford House
Davis, C. R.	Gulf General Atomic	San Diego, California	Hanford House
Davis, F. C.	Oak Ridge National Laboratory	Oak Ridge, Tennessee	Rivershore
Davis, James R.	Drake Sheahan/ Stewart Dougall, Inc.	New York, New York	Hanford House
Dean, Robert	U.S. Army	Aberdeen, Maryland	Imperial 400
Devine, Barry D.	Argonne National Laboratory	Argonne, Illinois	Rivershore
Duff, Robert T. (Col.)	USAEC	Washington, D.C.	Hanford House
Dufrane, K. H.	Nuclear Fuel Services, Inc.	Timonium, Maryland	Rivershore
Dunaway, D. L.	National Lead Company of Ohio	Cincinnati, Ohio	Hanford

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Dykstra, J.	Union Carbide Corporation	Oak Ridge, Tennessee	Rivershore
Edlow, S.	Edlow International Company	Washington, D.C.	Hanford House
Elder, R. I.	USAEC-Chicago	Naperville, Illinois	Bali Hi
Eldridge, C. C.	Bechtel Corp.	San Francisco, California	Bali Hi
Emswiler, T.	Battelle Memorial Institute	Columbus, Ohio	Rivershore
Endlich, J.	USAEC	Germantown, Maryland	Rivershore
Engholm, B. A.	Gulf General Atomic Company	San Diego, California	Rivershore
Erickson, Dean L.	Naval Nuclear Power Unit	Fort Belvoir, Virginia	Imperial 400
Evans, E. R.	Tri-State Motore Transit Co.	Idaho Falls, Idaho	Rivershore
Evans, J. H.	Oak Ridge National Laboratory	Oak Ridge, Tennessee	Rivershore
Faust, Homer M.	Battelle Columbus	Westerville, Ohio	Imperial 400
Fchaich, Robert	Union Carbide	Oak Ridge, Tennessee	Imperial 400
Feldscher, J. C.	Goodyear Aerospace	Akron, Ohio	Hanford House
Fernan, J.	American Trucking Associations, Inc.	Washington, D.C.	Hanford House
Fiss, Edward	Duke Power Co.	Charlotte, North Carolina	Hanford House
Foley, J. T.	Sandia Laboratories	Albuquerque, New Mexico	Hanford House
Foster, J. J.	General Electric	Scotia, New York	Rivershore
Fox, J. K.	Idaho Nuclear Corp.	Idaho Falls, Idaho	Rivershore
Frederick, E. J.	Oak Ridge Nat. Lab.	Oak Ridge, Tennessee	Hanford House
Freeman, A. T.	Union Carbide Corp. Nuclear Division	Paducah, Kentucky	Rivershore
Freeman, E. J.	Allied Chemical	Paducah, Kentucky	Red Lion

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Gablin, K.	Protective Packaging, Inc.	Tacoma, Washington	Hanford House
Gens, M. B.	Sandia Laboratories	Albuquerque, New Mexico	Hanford House
George, T. C.	U.S. Dept. of Transportation	New Rochelle, New York	Hanford House
Giebel, R. E.	Dow Chemical	Arvada, Colorado	Rivershore
Golliher, K. V.	Dow Chemical	Boulder, Colorado	Red Lion
Goodner, C. F.		Spokane, Washington	Hanford House
Grella, A. W.	U.S. Dept. of Transportation	Fairfax, Virginia	Hanford House
Grover, D. L.	Westinghouse Nuclear Energy Systems	McMurray, Pennsylvania	Rivershore
Grund, John E.	General Electric	Portland, Oregon	Hanford House
Hagler, Howard	Hittman Nuclear & Development Corp.	Columbia, Maryland	Rivershore
Hair, G. H.	E. I. duPont	Aiken, South Carolina	Rivershore
Hamilton, S. C.	The Dow Chemical Co.	Golden, Corlorado	Red Lion
Handshuh, J. W.	Southern Consolidated Edison	Rosemead, California	Hanford House
Hanson, C.	Lawrence Radiation Lab.	Livermore, California	Golden Door
Harper, J. A.	E. I. duPont de Nemours Savannah River Plant	Aiken, South Carolina	Rivershore
Herry, M.	Industrial Attache French Consolate	San Francisco, California	Red Lion
Hart, E. E.	U.C. Lawrence Berkeley Lab. Radiation Trans.	Berkeley, California	Red Lion
Harvey, J. L.	Nuclear Engrg.	Walnut Creek, California	Hanford House
Hasegawa, Ikuo	Sumitomo Shoji-America, Inc.	New York City, New York	Red Lion

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Hiller, K. A.	Whitehead & Kales Co.	New York City, New York	Red Lion
Holloway, C. J. Jr.,		Rockville, Maryland	Hanford House
Holloway, J. J.	Suntac Nuclear Corp.	Rockville, Maryland	Rivershore
Ishmael, C. E.	USAEC	Darien, Illinois	Bali Hi
James, H. V.	Norfolk Naval Shipyard	Portsmouth, Virginia	Bali Hi
Johnson, Alfred	U.S. Government	Falls Church, Virginia	Red Lion
Johnson, W. A.	USAEC	Knoxville, Tennessee	Hanford House
Jump, M. J.	Nuclear Fuel Services Inc.	Rockville, Maryland	Red Lion
Katsuragawa, M.	Argonne National Lab.	Downers Grove, Illinois	Bali Hi
Kaye, R. A.	Bureau of Motor Carrier Safety Dept. of Trans.	Washington, D.C.	Hanford House
Keller, C. L.	U.S. Coast Guard	Lanham, Maryland	Bali Hi
Kline, W. H.	Argonne National Lab.	Argonne, Illinois	Rivershore
Klingsberg, C.	National Academy of Sciences	Washington, D.C.	Rivershore
Koguchi, Toshio	Mitsubishi Atomic Power Ind., Inc.	Saitama-Pref., Japan	Rivershore
Kolb, Walter (Dr.)		F.R. Germany	Hanford House
Kotrappa, Payasada (Dr.)	Lovelace Foundation (also from Bhabha Research Center, Bombay, India)	Albuquerque, New Mexico	Imperial 400
Kropp, R. E.	Gulf United Nuclear Fuels Corporation	Guilford, Connecticut	Hanford House
Lamb, J. A.	USAEC	Oak Ridge, Tennessee	Hanford House
Langhaar, J. W.	Atomic Energy Div. duPont Co.	Kennett Square, Pennsylvania	Hanford House

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Lawrence, James N. P.	LASL	Los Alamos, New Mexico	Hanford House
Lecomte, P. A.	Sabena Belgian Airlines	Zaventem, Belgium	Hanford House
Lee, J. W.	Tri-State Motor Transit Co.	Joplin, Missouri	Hanford House
Lessard, Neil	Abbott Laboratories	Wildwood, Illinois	Hanford House
Lewallen, E. E.	E. I. duPont de Nemours	Aiken, South Carolina	Rivershore
Lindaman, E.	President, Whitman College	Spokane, Washington	Rivershore
Lovett, J. E.	Nuclear Materials & Equipment Corp	Export, Pennsylvania	Bali Hi
Loy, H. L.	General Electric	San Jose, California	Hanford House
Lucas, Henri D.	Commissariat à l'Energie Atomique	BOULOGNE-BILLANCOURT 92-France	Rivershore
Lusk, E. C.	Battelle Columbus Laboratories	Columbus Ohio	Hanford House
Lusky, R.	N. L. Industries, Inc.,	Albany, New York	Rivershore
MacDonald, Alex	Dept. of Transportation	Washington, D.C.	Hanford House
MacNeill, J. F.	N. L. Industries, Inc.,	Albany, New York	Rivershore
Maeser, P. H.	Idaho Nuclear Corp.	Idaho Falls Idaho	Bali Hi
Malmström, Heinf	STEAg Aktiengesell-schaft,	Essen, Germany	Rivershore
Mangusi, J.	Transnuclear, Inc.,	New York, New York	Rivershore
Marshall, D.	Idaho Nuclear Corp.	Idaho Falls, Idaho	Bali Hi
Matheny, G. B.	Consumer Power Co.	Jackson, Michigan	Hanford House

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Mayer, C.	Tri-State Motor Transit Co.	Joplin, Missouri	Hanford House
McBride, J. A.	E. R. Johnson Associates, Inc.	Bethesda, Maryland	Rivershore
McCarthy, J. D.	Dow Chemical Co.	Boulder, Colorado	Rivershore
McClister, J. J.	Tennessee Valley Authority	Chattanooga, Tennessee	Hanford House
McCluggage, W. C.	USAEC	Rockville, Maryland	Hanford House
McDonald, E. P.	Monsanto Research Corp. Mound Lab.	Miamisburg, Ohio	Hanford House
McKnight, Charles	Reynolds Electric & Engineering Co., Inc.	Las Vegas, Nevada	Red Lion
Mee, W. T.	Union Carbide Corp.	Rockwood, Tennessee	Hanford House
Messenger, W. de L. M.	United Kingdom Atomic Energy Authority	Warrington, Lancs England	Rivershore
Milau, J.	Associated Universities Brookhaven National Laboratory	Port Jefferson, New York	Rivershore
Moon, J.	Nuclear Engrg.	Walnut Creek, California	Hanford House
Moyer, R. A.	duPont, Savannah River Laboratory	Augusta, Georgia	Rivershore
Murphy, H. J.	Air Transport Association	McLean, Virginia	Hanford House
Murri, Ernie	Consumer Power Co.	Jackson, Michigan	Hanford House
Meyer, Walter (Dr.)	Kansas State U.	Manhatton Kansas	Red Lion
Neumann, A. T.	USAEC	Las Vegas, Nevada	Rivershore
Newlon, C. E.	Union Carbide	Knoxville, Tennessee	Rivershore
Nihei, Toyoo	Sankyu Trans. & Engr. Co.	New York City, New York	Red Lion
Noel, C. B.	Manson & Hanger-Silas Mason Co., Inc.	New London, Iowa	Rivershore
Noraz, M. R.	Evrochemic	MOL, Belgium	Hanford House

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Nussbaumer, D. A.	USAEC	Gaithersburg, Maryland	Hanford House
Olds, F. C.	Power Engineering Magazine	Barrington, Illinois	Hanford House
Onodera, A.	Hitachi Shipbuilding	Wilmington, Delaware	Hanford House
Partridge, A. H.	Department of the Environment	London SWI England	Hanford House
Perrette, J. R.	Transnuclear Inc.	New York, New York	Rivershore
Perrotti, Donald J.	Sm-1 Nuclear Power Plant	Fort Belvoir, Virginia	Imperial 400
Peterson, R. W.	Allied-Gulf Nuclear Services	Barnwell, South Carolina	Hanford House
Peterson, V. A.	Argonne National Laboratory	Idaho Falls, Idaho	Rivershore
Phillips, H.	Foster Wheeler Corp.	Metuchen, New Jersey	Rivershore
Pittman, Frank K. (Dr.)	USAEC Div. Waste Mngt.	Washington, D.C.	Hanford House
Poggi, Martin	GAMAH	Denver, Colorado	Red Lion
Pratt, G. W.	Burlington Northern Inc.	Seattle, Washington	Bali Hi
Priddy, Clarence N.	Mason & Hanger-Silas Mason Co., Inc.	Amarillo, Texas	Red Lion
Purcell, J. A.	Westinghouse Electric Corp., Nuclear Fuel	Columbia, South Carolina	Rivershore
Redon, Andre	CEA	S/Bagneux, France	Hanford House
Reeser, H.	Gulf General Atomic	Cardiff, California	Rivershore
Reid, H. B.	Chalk River Nuclear Laboratories	Chalk River, Ontario, Canada	Rivershore
Richards, N. W.	Pacific Power & Light	Lake Oswego, Oregon	Red Lion
Rigstad, N. L.	Idaho Nuclear Corp.	Idaho Falls, Idaho	Red Lion

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Risse, J. T.	Sandia Laboratories	Albuquerque, New Mexico	Red Lion
Robinson, B. M.	USAEC	Oak Ridge, Tennessee	Hanford House
Rogers, B. N.	U.S. Army Engineers Reactor Group	Ft. Belvoir, Virginia	Bali Hi
Rollins, J. D.	Nuclear Fuel Services Inc.	Gaithersburg, Maryland	Hanford House
Rusell, Thos.	Stone & Webster	Boston, Massachusetts	Hanford House
Rutland, L.	ATCOR Inc.	Elmsford, New York	Hanford House
Saltzman, J.	AEC	Bethesda, Maryland	Hanford House
Sanger, S. H.	Cabs Unlimited, Inc.	Mountain View, California	Rivershore
Sawyer, R. H.	U.S. General Accounting Office	Portland, Oregon	Rivershore
Saxena, Dinesh C.	General Electric	San Jose, California	Hanford House
Schaeffer, M. R.	RMI Company	Ashtabula, Ohio	Rivershore
Schendel, K. R.	Westinghouse Electric	Pittsburgh, Pennsylvania	Hanford House
Schmiedel, Friedrich		West-Germany	Hanford House
Schmidt, Gail D.	EHEW Public Health Service	Washington, D.C.	Columbia Camp Grounds
Schuler, C. J.	The Boeing Company	Wichita, Kansas	Red Lion
Schultz, C. W.	Bureau of Explosives	Edison, New Jersey	Red Lion
Schulz, Bernd		Berlin 48, Germany	Hanford House
Sciarra, B.	N L Industries, Inc.	Wilmington, Delaware	Rivershore
Scott, G. F.	USAEC Division of Waste & Scrap Mgmt.	Washington, D.C.	Hanford House

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Scruton, G. S.	O. G. Kelley Corp.	Needham, Massachusetts	Bali Hi
Seagren, Richard D.	Oak Ridge National Laboratory	Knoxville, Tennessee	Hanford House
Serkiz, A. W.	Battelle Memorial Institute	Worthington, Ohio	Hanford House
Shappert, L. B.	Oak Ridge National Laboratory	Oak Ridge, Tennessee	Hanford House
Shaw, W.	Canadian General Electric	Peterborough, Ontario, Canada	Rivershore
Shea, Dan	GAMAH	Denver, Colorado	Red Lion
Shon, F. J.	USAEC	Washington, D.C.	Hanford House
Short, L. E.	International Nuclear	Elizabethton, Tennessee	Hanford House
Shuster, Edward R.	NUMEC Nuc. Mat. & Equip.	Apollo, Pennsylvania	Red Lion
Simens, H. G.	Bechtel Corp.	San Francisco, California	Hanford House
Siple, Ralph	AEC-Idaho Field Office	Idaho Falls, Idaho	Imperial 400
Sisler, J. A.	USAEC, Transportation Branch	Gaithersburg, Maryland	Hanford House
Slusher, L. G.	Burlington Northern Inc.	Seattle, Washington	Bali Hi
Smith, C. H.	Select Committee on Small Business U.S. Senate	Washington, D.C.	Hanford
Smith, D. R.	Los Alamos Scientific Laboratory	Los Alamos, New Mexico	Red Lion
Smith, J. Alfred	B.N.F. Ltd. Risley	Warrington, England	Rivershore
Smith, J. L.	USAEC	Gaithersburg, Maryland	Hanford House
Stern, S.	Westinghouse-Bettis Atomic Power Lab.	Pittsburgh, Pennsylvania	Red Lion
Stock, A. J.	Stock Equipment Co.	Chagrin Falls, Ohio	Bali Hi
Stock, John R.	Stock Equipment Co.	Cleveland, Ohio	Red Lion

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Streed, D.	Uniroyal, Inc.	Mishawaka, Indiana	Rivershore
Swaney, T.	The Boeing Company	Wichita, Kansas	Red Lion
Swartz, H. A.	Westinghouse Electric Company-Bettis Atomic Power Laboratory	Bethel Park, Pennsylvania	Rivershore
Taylor, R. G.	Union Carbide Corp.	Oak Ridge, Tennessee	Rivershore
Taylor, W. R.	Atomic Energy of Canada Limited	Ontario, Canada	Rivershore
Thomas, J. T.	Union Carbide Corp.	Norris, Tennessee	Hanford House
Tremmel, E. B.	USAEC	Washington, D.C.	Hanford House
Trudeau, A. G. (Lt. Gen.)	Energy Consultants, Inc.	Chevy Chase, Maryland	Hanford House
Urbanowicz, W. A.	Atlas Car & Manufacturing Company	Cleveland, Ohio	Red Lion
Van Gorp, P. H.	Bechtel Corp.	San Francisco, California	Bali Hi
Vinarnick, Louis	Commissariat a l'Energie Atomique	Gif-sur-Yvette, France	Hanford House
Wackler, W. F.	Dow Chemical Co.	Arvada, Colorado	Red Lion
Wagstaff, David G.	Oregon State Board of Health	Portland, Oregon	Hanford House
Walchli, H.	Westinghouse Electric Corp.	Monroeville, Pennsylvania	Hanford House
Walter, C. W.	Union Carbide Corp.	Paducah, Kentucky	Hanford House
Ward, Daniel A.	Transportation Security	Annandale, Virginia	Hanford House
Whipple, G. Hoyt	University of Michigan	Ann Arbor, Michigan	Hanford House
Wilder, A.	N.L. Industries, Inc.	Elnora, New York	Rivershore

ATTENDEES (CONTINUED)

Name	Affiliation	Address	Motel
Williams, C.	N.A.S. Committee on Radioactive Waste	Bellport, New York	Hanford House
Williamson, Stanley	British Nuclear Fuels Limited	Lancashire, England	Rivershore
Wilson, B. D.	General Electric Co.	San Jose, California	Hanford House
Wyngaarden deLind van J.D.W.	Atomic Energy of Canada Limited	Ottawa, Ontario Canada	Hanford House
Zarbaugh, R. S.	Lawrence Radiation Laboratory	Livermore, California	Rivershore
Zünd, Hans	Motor Columbus Inc.	Switzerland	Hanford House

VISITING ATTENDEES (CONTINUED)

Name	Affiliation	Address
Aldrich, W.J.	Combustion Engineering	Windsor, Connecticut
Anselmo, A.A.	Aerojet Nuclear Co.	Idaho Falls, Idaho
Arnold, W.M.	Monsanto Mound Laboratory	Miamisburg, Ohio
Bartusek, J.F.	Argonne National Laboratory	Argonne, Illinois
Beaderstadt, D.E.	USAEC	Argonne, Illinois
Beard, S.J.	Jersey Nuclear Co.	Richland, Washington
Best, R.E.	Nuclear Fuel Services, Inc.	Rockville, Md.
Brasier, R.I.	Los Alamos Scientific Lab.	Los Alamos, New Mexico
Butcher, B.B.	Goodyear Aerospace	Bellevue, Washington
Byrd, Jr., C.C.	Washington State Department of Civil Defense	Olympia, Washington
Copenhauer, C.M.	USAEC - Oak Ridge Oper.	Oak Ridge, Tennessee
Corbett, J.S.	Clow Corporation Chem-Nuclear Services	Streator, Illinois
Crocker, H.W.	USAEC - Region I, Div. of Compliance	Newark, New Jersey
Crossley, E.J.	WRAMC	Washington, D.C.
DeVito, V.J.	Goodyear Atomic Corporation	Piketon, Ohio
Donham, Bob	LASL	Los Alamos, New Mexico
Edlow, Jack	Edlow International Co.	Washington, D.C.
Engel, W.P.	USAEC	Washington, D.C.
Estev, H.P.	Jersey Nuclear Co.	Richland, Washington
Fairey, J.	United Kingdom Atomic Energy Energy Authority	Aldermaston, Reading, Berkshire, England
Flagg, A.H.	Aerojet	Fullerton, California
Foust, David	Washington State University	Pullman, Washington

ATTENDEES (CONTINUED)

Name	Affiliation	Address
Gerring, F.H.	Goodyear Aerospace Corporation	Akron, Ohio
Graf, Jr., W.A.	General Electric Company	Saratoga, California
Gray, R.K.	Burlington Northern, Inc.	Woodinville, Washington
Gregory, Wm.	LASL	Los Alamos, New Mexico
Gulley, R.L.	Jersey Nuclear Co.	Richland, Washington
Haelsig, D.T.	Mechanics Research	Tacoma, Washington
Harris, Richard	Nuclear News	Hinsdale, Illinois
Hendron, Robert	LASL	Los Alamos, New Mexico
Hogle, Don	Atomics International	Richland, Washington
Johnson, Bill	Clow Corporation	Chicago, Illinois
Jones, R.H.	General Electric Company	San Jose, California
Kershner, C.M.	Allis-Chalmers	York, Pennsylvania
Keto, John	USAEC	Washington, D.C.
Kilbury, C.D.	Washington State Legislature	Pasco, Washington
Kogetsu, Morohiko	Mitsui & Co., Inc.	San Francisco, CA
Kreig, Delores M.	Dow Chemical Company	Golden, Colorado
Kvam, D.J.	Lawrence Livermore Lab.	Livermore, California
Loud, G.D.	TriState Motor Transit Co.	Springville, New York
McConnon, Dan	Rural Coop. Power Assoc. Elk River Reactor	Elk River, Minnesota
McCullugh, R.W.	Jersey Nuclear Co.	Richland, Washington
McMurray, P.R.	Jersey Nuclear Co.	Richland, Washington
McVey, W.H.	USAEC	Rockville, Maryland
Montgomery, R.A.	Tennessee Valley Authority	Knoxville, Tennessee
Nechodom, W.S.	Jersey Nuclear Co.	Richland, Washington

ATTENDEES (CONTINUED)

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Nowak, H.A.	USAEC - Headquarters	Germantown, Washington, D.C.
Odegaarden, R.H.	USAEC - Div. of Materials Licensing	Washington, D.C.
Orme, H.R.	Aerojet Nuclear Co.	Idaho Falls, Idaho
Penney, J. A.	Assoc. Univ. Inc. Brookhaven National Lab.	Upton, Long Island, New York
Penttilla, Arne	Rural Coop. Power Assoc. Elk River Reactor	Elk River, Minnesota
Poe, J. L.	Gray Tool Company	Houston, Texas
Prawlocki, Frank	Public Service Electric & Gas	Newark, New Jersey
Pryor, W.A.	USAEC	Oak Ridge, Tennessee
Reinig, L.P.	LASL	Los Alamos, New Mexico
Reis, Iris DeCastro	Grazilian AEC	Rio de Janeiro - Guanabara, Brazil
Ribaux, P.A.	Ateliers des Charmilles SA	Geneva, Switzerland
Ritter, G.	Jersey Nuclear Co.	Richland, Washington
Ruelius, P.C.	Drake Sheahan/ Stewart Dougall, Inc.	New York, New York
Sakamoto, T.	Marubeni, Iida Co., Ltd.	Chiyoda-ku, Tokyo, Japan
Saye, C.T.	The Boeing Co.	Wichita, Kansas
Schaich, R.W.	Oak Ridge National Laboratory	Oak Ridge, Tennessee
Schile, G.D.	U.S. Navy, NNPU	Fort Belvoir, Virginia
Seixas, Antonio F.V.	Brazilian AEC	Rio de Janeiro - Guanabara, Brazil
Shannon, Jack	Dairyland Power Coop.	Genoa, Wisconsin
Shultz, K.R.	Atomic Energy Control Board	Ottawa, Ontario, Canada

ATTENDEES (CONTINUED)

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Simmons, G.L.	National Bureau of Standards	Washington, D.C.
Smith, A.J.	British Nuclear Fuels Ltd.	Heaton Moor Stockport, Chesire, England
Smolen, S.G.	General Electric Co.	Morris, Illinois
Stevenson, R.L.	USAEC - Div. of Materials Licensing	Washington, D.C.
Sulek, E.W.	N. L. Industries	Wilmington, Delaware
Susanna, Antonio	Comitato Nazionale per L'Energia Nucleare	Rome, Italy
Swindle, D.R.	USAEC - Headquarters	Washington, D.C.
Tatalovich, S.D.	USAEC - Division of Internal Affairs	Washington, D.C.
Thiesing, J.W.	The Boeing Co.	Wichita, Kansas
Tidrick, Garry	Pacific Gas & Electric	San Francisco, CA
Trask, W.H.	Riggers Mfg. Co.	Kennewick, Washington
Tuite, P.T.	Hittman Nuclear & Dev. Corp.	Columbia, Maryland
Turner, L.L.	USAEC - SR	Aiken, South Carolina
Wescott, H. M.	U.S. Army	APO Seattle, WA
Westby, Robert	USAEC -SAN	Berkeley, California
Williams, J. M.	UAEC/OSMM	Washington, D.C.
Wuller, G.E.	Kerr McGee Corp, Nuclear Div.	Oklahoma City, Oklahoma

ATTENDEES USAEC-RLO AND SPONSORING HANFORD CONTRACTORS

Name	Affiliation	Name	Affiliation
Alford, M.D	ARHCO	Caudill, H.L.	Jersey Nuclear
Anderson, H.J.	WADCO	Christy, J.T.	AEC-RL
Anderson, H.E.	AEC-RL	Clayton, E.D.	BNW
Anderson, J.K.	WADCO	Colton, L.B.	WADCO
Anderson, R.D.	ARHCO	Colvin, C.A.	ARHCO
Asmund, V.C.	BNW	Condotta, D.L.	BNW
Atwood, J.M.	WADCO	Cooley, C.R.	WADCO
Backman, G,E.	ARHCO	Corley, J.P.	BNW
Bainard, W.D.	DUN	Craddock, L.E.	WADCO
Beaulieu, O.F.	ARHCO	Craig, D.A.	USAEC
Bell, J.R.	USAEC	Curren, E.F.	ARHCO
Bentley, B.W.	WADCO	Dabrowski, T.E.	DUN
Berger, D.N.	ARHCO	Darby, J.J.	Vitro
Berry, J.R.	BNW	Davenport, L.C.	BNW
Bevan, W.G.	ARHCO	Davis, H.S.	DUN
Blasewitz, A.G.	WADCO	DeMerschman, A.W.	WADCO
Blyckert, W.A.	ARHCO	Derouin, J.P.	USAEC
Brackenbush, L.W.	BNW	Dodd, A.O.	USAEC
Bray, G.R.	Vitro	Doriss, C.P.	DUN
Brown, C.L.	BNW	Dotson, W.R.	ARHCO
Carrothers, M.R.	USAEC-RL	Dunn, J.C.	BNW
Carter, N.E.	BNW	Elgert, O.J.	AEC-RL

ATTENDEES (CONTINUED)

Name	Affiliation	Name	Affiliation
Essig, T.H.	BNW	Hess, E.H.	USAEC
Fecht, J.B.	ARHCO	Hicks, H.G.	USAEC-RL
Fies, C.L.	WADCO	Hill, O.F.	ARHCO
Freitag, H.R.	USAEC-RL	Hoover, D.A.	ARHCO
Garrett, E.E.	WADCO	Hopkins, H.H.	ARHCO
Garrison, R.F.	USAEC-RL	Houston, J.R.	ARHCO
George, W.	USAEC-RL	Hultgren, R.A.	ARHCO
Granquist, D.P.	BNW	Jackson, M.D.	WADCO
Gruber, W.J.	WADCO	Johnston, E.M.	WADCO
Haase, K.W.	USAEC	Jordan, J.W.	ARHCO
Haberman, H.D.	Vitro	Kathren, R.L.	BNW
Hall, R.J.	BNW	Kelly W.S.	BNW
Hansen, L.E.	BNW	Kennedy, R.A.	ARHCO
Hanson, G.L.	ARHCO	Kirkman, M.J.	ARHCO
Harmsen, R.W.	USAEC	Kleinpeter, J.H.	Vitro
Harrison, C.W.	DUN	Knapp, D.A. (Ret.)	ITT
Harty, W.M.	ARHCO	Knights, L.M.	ARHCO
Heacock, H.W.	DUN	Koop, W.N.	ARHCO
Heid, K.R.	BNW	Koreis, E.H.	DUN
Henry, H.L.	BNW	Lampton, A.W.	USAEC-RL
Herald, R.C.	ARHCO	Lanning, D.D.	BNW

ATTENDEES (CONTINUED)

Name	Affiliation	Name	Affiliation
Lehfeldt, D.C.	BNW	O'Block, V.S	WADCO
Leitz, F.J.	WADCO	Oden, D.R.	BNW
Lloyd, R.C.	BNW	Oscarson, E.E.	ARHCO
Lotz, W.E.	USAEC-RL	Ostby, L.M.	BNW
Maxfield, H.L.	ARHCO	Paglieri, J.N.	WADCO
Mayfield, D.L.	BNW	Parker, H.M.	BNW
McElroy, J.L.	WADCO	Pedersen, L.T.	BNW
McKenzie, T.R.	ARHCO	Penn, G.F.	USAEC
McLerran, S.J.	DUN	Perkins, L.F.	USAEC
McMurray, B.J.	ARHCO	Platt, A.M.	BNW
Melton, B.J.	USAEC-RL	Powers, C.S.	BNW
Mendel, J.E.	WADCO	Prezbindowski, D.L.	BNW
Mertes, J.V.	BNW	Prudich, T.	DUN
Metzger, F.S.	WADCO	Purcell, R.H.	BNW
Mishima, J.	BNW	Ranson, H.E.	USAEC-RL
Moore, J.D.	ARHCO	Rasmussen, M.J.	USAEC-RL
Moulthrop, H.A.	ARHCO	Ridgeay, K.R.	ARHCO
Myers, J.G.	DUN	Riehl, J.A.	BNW
Newman, D.R.	BNW	Roesch, R.E.	USAEC
Newton, H.J.	USAEC-RL	Rokkan, B.J.	USAEC
Nitteberg, L.J.	WADCO	Rosson, R.L.	Vitro

ATTENDEES (CONTINUED)

Name	Affiliation	Name	Affiliation
Rutherford, M.J.	Vitro	Stubblefield, F.E.	USAEC-RL
Salzano, G.H.	Vitro	Templeton, D.W.	USAEC-RL
Sammis, J.E.	WADCO	Titzler, P.A.	WADCO
Schmid, L.C.	BNW	Toffer, H.	DUN
Schneider, K.J.	BNW	Unruh, C.M.	BNW
Schwankoff, A.R.	USAEC	Vladimiroff, D.T.	ARHCO
Schwendiman, L.C.	BNW	Watson, E.C.	BNW
Scott, O.D.	ARHCO	White, J.D.	USAEC-RL
Selby, J.M.	BNW	Williams, D.G.	USAEC-RL
Shaw, H.D.	ARHCO	Williams, F.J.	USAEC
Shoaf, D.C.	WADCO	Wilson, R.E.	BNW
Short, A.	Vitro	Wilson, R.H.	ARHCO
Siems, K.H.	BNW	Wirfs, L.F.	BNW
Simpson, G.	WADCO	Wittenbrock, N.G.	BNW
Smith, R.C.	WADCO	Wodrich, D.D.	ARHCO
Smith, R.E.	ARHCO	Woodfield, F.W.	BNW
Soehnlein, J.H.	BNW	Yesberger, G.R.	USAEC
Stewart, D.H.	BNW	Zangar, C.N.	Vitro
Stidham, H.C.	BNW	Zelley, F.J.	BNW
Stoakes, J.S.	BNW	Zimmerman, M.G.	BNW

KEYNOTE ADDRESS

REMARKS BY BENJAMIN O. DAVIS, JR., ASSISTANT SECRETARY OF TRANSPORTATION FOR SAFETY AND CONSUMER AFFAIRS BEFORE THE THIRD INTERNATIONAL SYMPOSIUM ON PACKAGING AND TRANSPORTATION OF RADIOACTIVE MATERIALS RICHLAND, WASHINGTON, AUGUST 16, 1971

I am delighted to have this opportunity to be with you this morning. I have been involved with the Department of Transportation's hazardous materials program only since July 1--not quite seven weeks. Considering that many of you have been working with the problems of transporting radioactive materials for as much as 25 years, it may seem presumptuous for me to be here attempting to set the keynote for this symposium. But I've had a lot of good advice from some of our Department of Transportation experts--people like Bill Burns and Al Grella--so here goes.

I'll begin by going back to about the time this industry started--back to April 16, 1947--back to Texas City, Texas. That day a French freighter, the S. S. Grandcamp, was loading ammonium nitrate for shipment to Europe for agricultural purposes. Ammonium nitrate, of course, is an ingredient of some explosives. Some 2,300 tons of the chemical had been loaded when a fire broke out in one of the ship's holds. The master--apparently thinking of his cargo in terms of fertilizer rather than explosives--made a mistake. Instead of flooding the fire, he attempted to smother it by sealing the hold and piping in steam. A sensible tactic in many cases, but it can't work with ammonium nitrate. The ship exploded, destroying the docks and most of the city. Five hundred and sixty-eight people were killed; 2,000 to 3,000 people were injured; total damage was about $67 million.

Since then, hazardous materials have scourged many communities--South Amboy, New Jersey; Roseburg, Oregon; Laurel, Mississippi; Crete, Nebraska; Dunreith, Indiana; Brooklyn, New York--each will remember its day for a long time.

In 1970 President Nixon and Secretary Volpe succeeded in getting enacted the first comprehensive railroad safety bill in history--a law which also provides for greater authority over the transportation of hazardous materials. Much of the impetus for passing the Railroad Safety Act was supplied by several spectacular derailment accidents and by the public's exceedingly great concern over Defense Department shipments of poison gases for disposal. Events such as these are very visible and emotional. Less visible, but equally sobering, is the fact that chemical production in the United States over the past 15 years has increased by more than 375 percent. And that percentage growth is applied to a base that 15 years ago was already very substantial.

Each year more than 500 new chemicals are developed, most of which eventually get into the transportation environment. The volume of hazardous materials moving in our transportation system records a parallel growth so that each passing day exposes the public to an increasing degree of risk. To offset this danger, we must work constantly for better packaging and for safer transport.

The rapid development of new substances makes it infeasible to attempt to set packaging standards on a specification basis. I prefer to rely on performance standards--tell the industry the level of safety it must attain and then let it do the job the best way it can. New substances may require new and innovative containers. If our research chemists develop a universal solvent, someone is going to have to come up with something to put it in.

Passage of the Railroad Safety Act last year reflects the serious concern the Federal Government feels for the problems of railroad safety and the transportation of hazardous materials. Title III of the Act--entitled the Hazardous Materials Transportation Control Act--is the most significant piece of legislation relating to the safe transport of hazardous materials since the original Transportation of Explosives Act back in 1908.

The new Act directs the Secretary of Transportation to:

1. Establish facilities and staff to evaluate the dangers of shipping hazardous materials;

2. Establish a central reporting system for hazardous materials accidents which will provide information and advice to emergency crews working to handle an accident involving hazardous materials; and

3. Review all aspects of hazardous materials transportation to determine the appropriate steps to be taken immediately to provide for safer movement of such materials.

The Department of Transportation's Office of Hazardous Materials is now working to implement this law. On January 1 of this year, it established a new uniform, multi-modal hazardous materials incident reporting system. With this system, we can get and analyze the data we so vitally need if we are to maintain a current capability to cope with all of the hazardous materials being shipped today and those developed tomorrow.

In the near future, we will propose a completely new system for multi-modal hazardous materials package labels and placards. It will be called the "HI" system--for Hazardous Information--and will encompass the major elements of the United Nations hazardous materials classifications. This system's objective is to provide complete and rapid identification of hazardous materials involved in a transportation accident--information that is vital to fire, police and other emergency response personnel.

We have begun an extensive effort to determine more appropriate hazardous materials classifications. Our 1971 appropriation for this work was $180, 000 and we have requested an additional $50, 000 to continue the work in this fiscal year.

Recently we began a series of one-week training courses on the transportation of hazardous materials. They are being held at universities in various parts of the country and are being very well received.

The regulatory standards for radioactive materials are well established, thanks, primarily, to an attitude that has prevailed right from the beginning--that safety is a prime program objective. With most non-radioactive hazardous materials, safety has to play catch-up. Much of the credit must also go to the harmonious relationship between the Atomic Energy Commission and the Department of Transportation. The memorandum of understanding between these agencies is being updated and Al Grella will have detailed information on that, as well as on the Department's present regulatory role, in his paper this afternoon.

The transportation safety record of your industry is phenomenal--not a single death from radioactive materials in 25 years of operations. The only transportation enterprise that can match that are the NASA space flights. Both share a common premise--absolute safety is mandatory.

During the past 25 years a lot of people have been killed and injured in accidents involving other hazardous materials. The public is apprehensive about these accidents, but not alarmed. Perhaps unconsciously, the public has erected a rather high acceptable risk threshhold for non-radioactive materials. In spite of the fact that they are the most safely transported of all hazardous materials, the public has no risk threshhold whatever for radioactive materials.

Public fear originates from the introduction of nuclear energy to the world in the form of a weapon. The awesome spectre of the mushroom cloud haunts our memory. Psychologically, the average citizen is better able to cope with the yellow cloud of poisonous gas, the petrochemical fireball, or the blast of dynamite. He fears these things--and rightly so--but they are tangible dangers--things that he can see or hear or feel. Radioactivity is an invisible force which can strike him without his being aware of any danger at all.

I was told a story recently which illustrates this point in a light vein. It happened some time ago at a place not too far from Richland. A railroad boxcar carrying material from Hanford derailed and fell into a river. When a railroad crane was pulling the car back onto the roadbed, a door opened and some containers fell out and broke open. One of the two AEC safety officers observing the salvage operations wanted to record the scene and ran back towards his car to get a camera. He hadn't gone far when the crane operator sped past him. The spilled materials on the embankment was as harmless as it looked but it took some convincing to get the crane operator back to work.

Obviously, we have to get back to work educating the public so that they are able to understand the great potential good that lies with the use of nuclear materials and know what the dangers really are. The public needs to develop a sound perspective for viewing the transportation and use of these materials.

Electricity is going to play an increasing role in meeting future energy demands. Today 25 percent of the energy requirements in the United States are met by electricity; by the year 2000 the forecast is 50 percent. Some people complain that power plants are major polluters and that we should cut back on power demands. But these people overlook the fact that power plants burning coal and oil are much more efficient, and must less polluting, than would be possible if electricity users individually had to burn coal or oil for their energy requirements.

A major contributor--if not the major contributor--to air pollution is the transportation system, particularly motor vehicles. One-tenth of one percent of transportation in this country is powered by electricity. The Department of Transportation is trying to foster development of non-polluting transport systems. To do that, propulsion systems must depend heavily on electricity.

To improve our environment we are going to have to rely on more, not less, electricity. The fission power plants of today and the fusion plants of tomorrow will play an increasingly greater role in meeting this demand. And that means there is going to be a lot more readioactive materials moving about this country than there is today.

On July 27 in Washington, AEC Chairman Seaborg spoke on the subject of nuclear energy and the environment. He detailed some possible impacts of a hypothetical national moratorium on nuclear power development. If you are not familiar with the speech, I commend it to you. Ecology is in fashion today but we have few ecologists. Most people concerned with ecology are simply against something and are unaware that ecology involves a complex system of balanced forces. Strengthen or eliminate one force and the system changes.

Dr. Seaborg points out that today there are "too many people who, alarmed by current environmental conditions, seem too willing to throw up their hands in despair, who are giving up too soon on the human race, on its intelligence and its ability to meet challenges with new creativity."

That kind of attitude cripples sensible development of our nuclear industry. People are afraid that an accident might cause a power plant or a railroad car carrying enriched uranium to explode. The procedure for getting uranium to detonate is exceedingly complex; it can't happen spontaneously. If there were an excursion, or runaway, of a power plant reactor--which presupposes simultaneous failure of all safety control systems--the reactor core might melt but it wouldn't explode. And fission would stop.

If an accident stops fission in a system designed ideally to sustain it, it is extremely unlikely that nuclear fission could be started by a transportation accident. Packaging systems, of course, are specifically designed to prevent that extreme unlikelihood from developing even in the worst credible accident.

If the public is ever going to regard nuclear materials as just one of many hazardous materials, it must be much more knowledgeable than it is today. The burden of providing the necessary education falls on the shoulders of people like you. Aside from Admiral Rickover, you can't expect people to assign much credibility to a former military man on a subject of this nature.

To be effective, you must maintain your perspective too. When you talk with colleagues at meetings such as this one, you speak with a common understanding of the problem. Don't make the mistake of thinking that the general public shares even a smattering of this understanding. Their fears are real and very deep-rooted. The education task is a formidable one.

We have had a whole generation grow up in this country regarding air travel as commonplace. Across the generation gap their elders still regard flying with wonderment. Perhaps in another generation people will accept the risks and benefits of nuclear technology for what they really are.

The major technical concern for hazardous materials today seems to me to be in the packaging of materials for transportation. Until we are able to improve substantially on the safety of our transport system, we have to anticipate transportation accidents and design our packaging to withstand these accidents without catastrophic results. The Department of Transportation is making a determined effort to make transport as safe as possible but it is going to take a long time.

The risks associated with transporting hazardous materials have been carefully considered in establishing the current safety standards. These standards are not perfect--not by any means--but they have performed their job quite well. They will be modified from time to time as we gain experience and as a result of symposiums such as this one.

If there is one keynote I can strike for this symposium, it is "get the word out and see that the word is understood." Talk to the people who are concerned--to schools, to news media, to community groups. People are being pulled into tomorrow's technology and they aren't prepared. It's up to you to help them handle it.

I wish you every success this week in your discussions.

SYMPOSIUM LEAD PAPER

Remarks Prepared by
Ernest B. Tremmel and Robert J. Berte
Division of Industrial Participation
U. S. Atomic Energy Commission

Before
Third International Symposium
Packaging and Transportation of Radioactive Materials
Richland, Washington
August 16, 1971

TRENDS IN NUCLEAR TRANSPORTATION

Introduction

I am especially pleased to be here today to discuss with you some trends in nuclear transportation. The spent fuel and waste management area of transportation has been slower in developing than some of the other segments of the nuclear industry and it is certainly appropriate to focus on packaging and transportation of radioactive materials in the broad framework that this Third International Symposium provides. This symposium also gives me an opportunity to visit Richland again and become better acquainted with the programs and development of this community.

Many organizations have analyzed the nuclear power industry over the past several years in topical meetings ranging from nuclear fuel financing to pressure vessels. Each of the previous two International Symposia in 1965 and 1968 and more recent conferences such as the SINB Conference in February 1970 and the University of Virginia Symposia in 1969 and 1970 have dealt with shipping of radioactive materials in considerable detail. Speakers to follow at this symposium will be concerned with a host of technical, regulatory and operational details relating to transportation and packaging of various radioactive materials.

I would like to lead off the symposium by reviewing some of our projections for nuclear power plants and of requirements and markets for materials and components for the next 10-15 years so that you may have a better feeling for the dimensions of the nuclear power and resulting transportation industry that will be necessary to support it. Because of the way the atomic energy program evolved from weapons to peaceful uses, facilities like enriching plants are located some distance apart, ore is mined far from where it will be processed or used, reprocessing plants tend to be large in capacity and certainly few in number in the next ten years and, of course, the utilities must locate nuclear power plants as close to their markets as possible. The overall importance of transportation is, therefore, much greater in the presently developing system than it would have been, for example, if concentrated nuclear power clusters had been developed each with its own enriching, fabrication and reprocessing capability.

As I'm sure all of you know, in the U.S. our Atomic Energy Program was born a government monopoly and a private industry was subsequently created by the AEC later on. The only two segments not yet fully defined in this industry are enriching and spent fuel and waste transportation. The AEC announced in June a program to permit private companies to have access to enrichment technology. The spent fuel and waste transportation industry is not yet clearly defined because it is one of the last steps in the fuel cycle. The following brief review of some of the more important aspects of the energy picture and of the role that we see for nuclear power should help to provide a background and perspective in regard to the transportation of radioactive materials.

Why do we need nuclear power?

In talking about the need for anything, first we must talk about people. My first slide shows the trend in population in the United States, and you will notice that it is doubling about every 50 years. If this trend continues, obviously we need more electric power if we are to maintain our present way of life. Apparently the trend will continue unless some restriction is placed on the number of children that are to be born, and the level of immigration permitted into the United States. If a woman is allowed only two children and immigration is cut to zero, both of which may be rather unrealistic, then the population in the United States according to this projection would level off at 276 million in the year 2037. Not only does the increase in population require additional electric power, there has been a trend in the per capita use of energy in the United States, as shown on Slide 2. In Slide 3, one can see that the rate of increase in per capita use of energy is about the same as the rate of increase in population. However, the increase in the use of electricity per person is at a much higher rate. This is one reason that the increase in the requirement for electricity in the United States doubles about every ten years, as compared to a doubling in the population about every 50 years. It is well known that the people in the United States enjoy a high standard of living and this is possible to some extent because of the large per capita availability of electricity. The rest of the world is also experiencing a similar problem in population growth and demand for more and more power.

Slide 4 shows the per capita production of electricity in the United States as compared with some other countries of the world. The per capita production in Canada is higher than in the U.S. because of their relatively small population and high use in heavy industry as aluminum production.

In my judgment, I think it is rather impractical to talk about turning away from our present way of life. In fact, I believe the per capita use of electricity is going to increase rather than decrease (as some think it should through restrictions) because of the welcome trend in this country to make available to the underprivileged the many advantages that many of us are enjoying today through the use of electricity. In fact the future demand for electricity will no doubt increase as it is used more and more to improve our environment through the reprocessing of waste products into useful products, and through the use of mass transit systems to eliminate some of the air pollution problems. If the standard of living is to be increased in other countries of the world, the growth in demand for electricity will be even greater in the underdeveloped countries.

It has been said by some prophets of doom that gas, oil, coal and uranium reserves are in short supply and are being rapidly exhausted. In contrast, it has also been said by the optimists that there are enough coal reserves in the United States at the present rate of consumption to last a thousand years, and that there is enough uranium in the United States to last thousands of years with development of the breeder reactor, and beyond that, with the future development of fusion reactors, enough fuel through that technology to last millions of years. Maybe a realistic approach is to consider that the lifetime of the supply of fuel in any one of these categories depends to a large extent on the price that one is willing to pay to recover this fuel from the earth's crust. Slide 5 shows one estimate of the availability of energy resources for present day economics in the production of electric power. The important point is that we need all of the sources of fuel. In some cases we may be able to take advantage of geothermal power, of tidal power, and even solar power, and it is hopeful that magneto hydrodynamics will be developed as a more efficient means of converting heat energy into electric energy. But in general these additional sources of power will be small in comparison to total requirements.

In Slide 6 is shown a projection of the electric generating capacity expected in the United States through the year 1990, and the various sources of power. One can see that even by 1990 the amount of power provided by nuclear reactors is still less than the amount provided by coal, oil and gas.

Forecasts, as shown in Slide 7, indicate that the use of gas and oil, at least for electric power will remain rather constant in comparison to a rather rapid increase in the use of coal for the production of electricity. These projections appear fairly realistic based on current experience in the orders for steam-supply systems. Of course, the future trend in orders for nuclear plants vs. fossil plants can only be based on educated estimates. There probably will be a variation from year to year, as there has been in the past (Slide 8), and orders will be based primarily on economics in my judgment, and not on the estimates of reserves, at least in the case of coal and uranium.

The electric power equipment manufacturers are now committed to large capital expenditures in their facilities to manufacture and sell nuclear power plants. There are presently in operation, under construction or on order over 99,000 megawatts of electric nuclear power plant capacity. This is about twice as much electric generating capacity that existed in the United States at the end of World War II.

The fuel generating cost for a nuclear plant is much less than for a fossil plant. However, the capital cost for a nuclear plant is higher than the capital cost for a fossil plant. Therefore, a careful cost analysis must be made to determine the lowest overall cost of producing electricity so that sound decisions can be made regarding which type of plant to buy.

How many nuclear power plants are operating?

Slide 9 shows that at the end of 1968 there were 12 nuclear power plants in operation with a total generating capacity of 2,814 Mwe. It also shows the addition of three nuclear plants in 1969 totaling 1,450 Mwe, four nuclear plants in 1970 totaling 2,658 Mwe and 11 plants totaling 7,674 Mwe scheduled for startup in 1971. In Slide 10, the map of the United States show the location of all the plants in operation, under construction, or on order. In summary, there are 121 plants in operation, under construction, or on order, with a total capacity of over 99,000 megawatts.

The growth of nuclear power around the world is shown in the next Slide 11, and you can see that the United States leads the world in the number of plants ordered, in construction and in operation.

There has been considerable difficulty in getting these nuclear power plants constructed and in operation on the time scale that was originally expected by the utilities. Slide 12 shows what the experience has been. The curve is a projection by Dr. Paul Fine of our Division of Operations Analysis and Forecasting, which he made in 1967, that about 150,000 megawatts electrical would be put into operation by the end of 1980. We feel, however, that this forecast is still rather realistic. The present utility schedules for plant operation indicate that installed capacity will be above or on the 1967 AEC projected growth curve from 1972 through 1977. To stay on the growth curve, and, assuming a lead time of six years, orders must be maintained at about 15 plants per year on the average through 1974, in order to meet the estimate of 150,000 Mwe installed capacity by the end of 1980.

<u>In nuclear power economical?</u>

Again, one must ask, in comparison with what? Last October we talked with various architect engineers around the country on what their experience was in the capital cost of gas, oil, coal and nuclear power plants. These costs, of course, varied around the country. Slide 13 shows a tabulation of the range of these costs, and if one assumes the cost of nuclear fuel to be 16¢ per million Btu, which is a reasonable figure, then the break-even cost with other types of fuel is shown in the table. For example, if the capital cost of a nuclear plant is $50 per kilowatt electrical higher than the capital cost of a fossil plant, then the breakeven cost would be about 30¢ per million Btu. In other words, in those areas where this capital cost situation exists, and where the fuel cost for fossil exceeds 30¢ per million Btu, then it would be cheaper to purchase a nuclear plant to obtain an overall lower cost of producing the electricity. Capital costs shown for nuclear plants were for plants coming into operation during 1975 or early 1976. Now this picture has changed considerably. The average capital cost of a nuclear plant is something like $275 per kilowatt electrical, and in some cases, more than $300 per kilowatt electrical. This would be for plants expected to become operational by the end of 1977. Of course the capital costs can increase considerably for both nuclear and fossil plants in cases where cooling towers would be required. This could add about $25 per Kwe for dry cooling towers, and in the case of nuclear plants where improved radioactive waste handling equipment is installed, could add $3 per kilowatt electrical to the capital cost of the plant. I might caution that the game of estimating capital cost is a very difficult one because of the many variables involved and the manner in which a particular utility manages its financing, accounting and construction. A recent paper by Gerry Rhode of Niagra Mohawk Corporation discusses capital cost trends for fossil and nuclear plants in detail. Some utilities use retained earnings for a portion of their financing, where others do not. Some utilities capitalize costs of money during construction, and others do not. And in the case where the utilities have their own engineering and construction force, capital costs could be less because of the difference in productivity, management of the labor force, and the manner in which overhead is handled. Therefore, capital costs not only vary with the geographical section of the country, they vary significantly within a given geographical area. I might add that with coal going up to as much as 48¢ per million Btu and oil up to 54¢ per million Btu, even in the Southeast, and with the difficulty in obtaining long term gas supplies and also with gas increasing to 40¢ per million Btu in gas country, it seem that nuclear power is in a very good competitive situation at this time.

Nuclear power business prospects

We can make a fairly good estimate of the magnitude of the nuclear power business both for capital equipment and construction, and for the fuel cycle costs through the year 1980, and one can extend these estimates based on the projected growth of nuclear power of about 300,000 megawatts electrical installed capacity by the end of 1985, as shown in Slide 14. These projections are given in detail in WASH 1139, "Forecast of Growth of Nuclear Power" prepared by AEC's Division of Operations Analysis and Forecasting. Slide 15 shows that the annual expenditures for capital equipment and construction during 1970 was about $2 billion. This will increase on an annual basis to more than $10 billion during the year 1985. The nuclear steam supply expenditures yearly, as indicated in Slide 15 were $300 million in 1970, and this will increase to $1.4 billion for the year 1985.

Slide 16 is a further breakdown of the nuclear steam supply system, which indicated in 1985 the relative magnitude of business in the various components. This shows that the annual business for the nuclear steam supply system is about the same magnitude as that for the turbine generator market.

Nuclear fuel cycle costs through the year 1985 are shown on Slide 17. The expenditures for 1970 were about $200 million. This will increase on an annual basis to over $3 billion by 1985. A breakdown of nuclear fuel cycle costs in 1985, as shown on Slide 18 shows the relative value of the various steps in the fuel cycle. It is interesting to note that the enriching is the most costly step and of the same magnitude as the nuclear steam supply system and the turbine generators. Incidentally, the enriching step in the fuel cycle is the only step that is being performed by the Government at the present time. All the other steps are being performed by industry on a competitive basis.

Summarized by the use of Slide 19, the total magnitude of this nuclear business for capital equipment and plant construction through 1985 is estimated at $100 billion, and for the fuel cycle - $23 billion. In addition to this strictly domestic business, we estimate that an additional $4.35 billion revenue at the rate of $590 million in 1985 will result from enriching for foreign customers. The conversion of U_3O_8 to UF_6 feed for this amount of enriching business will be worth about $520 million at an annual rate of $70 million in 1985.

Incidentally, the value of nuclear power plants presently on order and the supply of fuel for their lifetime of 30 years is around $60 billion. You can see that nuclear power is here. American industry has made a big investment and the future looks bright.

Transportation Considerations

Before proceeding with more specific material on transportation, I wish to emphasize that we are pleased to assist private companies and others who need information concerning opportunities in the nuclear market place. We try to be realistic in presenting information about nuclear opportunities so that we do not encourage too many companies to enter any field where there already exists considerable competition.

I do not plan to discuss regulatory matters or the nature of packaging or transportation R&D being performed but want to attempt to show some dimensions, trends and approximate timing in nuclear fuel cycle transport.

Slide 20 shows the annual quantities of fuel materials that move from the uranium mines through the nuclear fuel cycle up through the reprocessing of spent fuel assemblies for a typical 1000 Mwe PWR nuclear power plant. Slide 21 shows the total annual transportation of fuel materials for the typical 1000 Mwe PWR and also for a comparable size coal fired plant. As you will note, there is a factor of about 100 difference in amount of material in favor of nuclear power.

Most of the packaging requirements for the beginning steps of the fuel cycle are met with conventional, easily manufactured containers, such as fiber or steel drum gas cylinders or specially constructed drums for enriched UF_6, for natural UF_6 feed to the gaseous diffusion plants and for gaseous diffusion plant tailings.

Spent Fuel Shipment

The principle and really large market for transportation in the nuclear fuel cycle is the spent fuel discharged from the reactor which must move to the reprocessing plant. Slide 22 indicates estimated annual quantities of uranium in discharged spent fuel. The $5 per kilogram uranium shipping cost used in preparing this estimate was obtained from various AEC reports; however, we are aware that others have advanced reasons to use higher shipping costs.

While factors such as transportation rates, insurance, and special handling charges would tend to balance out in calculations of the average cost of shipping spent fuels made by different individuals, important factors such as cask amortization period, mode of transport and cask pay load have significant effects on the cost. Shipping costs, therefore, could increase substantially over the $5 per kilogram uranium figure which was based on rail transport of large multi-element casks.

From reports and information we receive from various industry sources, it appears that only about one-half of the reactor facilities now in operation or planned have rail facilities. Some 10 percent could use barge, but none have used this mode as yet. There will no doubt be some inter-modal barge to rail or heavy-haul truck to rail spent fuel shipments from these reactor facilities to best economize on the use of larger casks. Therefore, we expect about half of the spent fuel will have to be transported by truck. The SINB Southern Governor's Conference last year clearly showed the impact that current state highway weight limitations imposed on shipping economies. Others in this conference will enlarge on the economy of shipping spent fuel, but the effects of shipping only one PWR or two BWR spent fuel elements in a single truck cask are apparent. The 1970 SINB Southern Governor's report make a strong case for increasing truck weight limitations for spent fuel shipping under certain conditions. There is also a comprehensive report on transportation of nuclear fuel material by the Nuclear Assurance Corporation of Atlanta, Georgia, which was prepared from data in their fuel-trac information and analysis service.

Depleted Uranium vs. Lead Shipping Casks

We have heard of the various benefits that will be obtained from the use of depleted uranium in place of lead casks. The principal advantages are increased strength, greater resistance to fire, and lower weight for a given size cask. The principal disadvantage is higher cost. One of our good friends in the cask design business, has estimated that on a comparable basis, that is, excluding engineering, licensing and quality assurance costs, a depleted uranium cask would cost around $6 to $7 per pound to fabricate while a lead cask costs around $1 per pound. The depleted uranium in a one element PWR truck cask would amount to around 30,000 lb. and a complete uranium cask loaded with PWR element would weigh around 43,000 pounds. If fabricated of lead, it would weigh 48,000 lb. Assuming a cask meets licensing requirements, it would appear difficult to justify uranium even if you have available some no-cost depleted uranium UF_6 tails from toll enriching.

The difficulties anticipated in the shipment of high value, high burn-up LMFBR fuels may prove to be the most compelling reasons to go to depleted uranium. In fact, in order to design a cask that does not exceed highway limits, it may be necessary to go to depleted uranium. These fuels have a high inventory charge and, therefore, for economic reasons should be reprocessed as soon as possible after discharge from the reactor.

Will there be a near-term shortage of spent fuel shipping casks?

From our discussions with the shippers and the AEC regulatory staff, it appears that there probably will be a shortage of spent fuel shipping casks capable of transporting the second generation water reactor fuel assemblies for the next four or five years. The currently available shipping casks are listed in the Appendix. These casks are only capable of handling the short (around 11 1/2 feet) first generation reactor fuel assemblies. New casks are being designed and some are in the licensing process that will be able to transport the longer (14 feet and over) second generation reactor fuel assemblies. Design of new casks to provide all of the normal safety, heat removal, and containment functions, and, in addition, provide shielding for the fast neutrons from curium-244 in high burn-up fuel is becoming much more complex and time consuming. Companies providing shipping cask design and fabrication are listed in the Appendix.

The simple fact that a wide variation exists in reactor site spent fuel storage facilities capability will require that more spent fuel casks be built than necessary had consideration been given to standardization in this area a few years ago. For the near term, that is the next two years, we have checked with the industry and Nuclear Assurance Corporation fuel-trac reports, and have identified those discharged spent fuels that will most likely require shipping. This information is shown in the Appendix.

Only those reactor fuel discharges which should have cooled sufficiently and also could be physically shipped during 1972 and 1973 have been included. There are about 57 metric tons of uranium in some 125 PWR fuel assemblies for 1972 and about 245 metric tons of uranium in around 330 PWR and 480 BWR fuel assemblies for 1973 that should require shipping in this time period. Several new spent fuel shipping casks will be required to move this fuel, the number being primarily dependent on how much would go by rail and how much by truck. In general, we estimate that each of the three spent fuel reprocessors (NFS, Allied-Gulf, and GE) will require from 3 to 6 truck casks (capacity 1 PWR or 2 BWR assemblies) and around 2 multi-element rail casks (capacity 3 PWR or 6 BWR assemblies) to meet the requirements through 1973.

Radioactive Wastes - A New Dimension in the Fuel Cycle

While radioactive wastes are generated in many areas of the nuclear industry such as the isotopes processing industry, hospitals and industrial laboratories using isotopes for testing, these wastes are relatively minor in amount and in quantity of radioactivity and have been collected by commercial firms at commercial burial sites since 1962. The principal area of concern is the radioactive wastes that are generated at the tail end of the nuclear fuel cycle during spent fuel reprocessing. I have some projections of quantities of these wastes that will require transporting and burial either in surface facilities or in a salt mine facility. Bill Brobst has a paper that will deal with salt mine transportation systems and their specific problems later, but I believe a brief look at the expected growth of this important area will help provide background for following papers.

Again using our standard 1000 Mwe BWR or PWR power reactor, here are some annual "handy-dandy" rule of thumb figures that can be used to make your own estimates of waste volumes. Radioactive traces of impurities such as iron, nickel and other corrosion products produced in the primary reactor coolant loop are removed from the system in ion exchange resin columns. The radioactive resins in these treatment systems are removed from the system, mixed with cement poured into 55 gallon drums, stored and then shipped to a licensed commercial waste disposal facility (not a salt mine). Roughly 500 cubic feet of radioactive resins are discharged each year from a 1000 Mwe reactor. A table of the estimated annual reactor resin waste generation and burial charges are contained in the Appendix.

The next waste form, high-level solid wastes, will be generated in increasing quantities corresponding to the anticipated growth of the nuclear power industry. The high-level liquid wastes resulting from spent fuel reprocessing must now be treated to conform to new Commission regulations which require the reprocessors to solidify such wastes within 5 years and move them to a federal repository within 10 years of production. Depending upon the solidification process and the burn-up of the spent fuel reprocessed, there will be about 2 cubic feet of high-level solid waste produced per metric ton of uranium processed at burn-ups of around 20,000 Mwd/ton. Greater fuel burn-up would increase the volume of waste and improvements in the solidification process could tend to reduce it. Each 1000 Mwe power reactor discharges roughly 30 metric tons of uranium in spent fuel annually so there will be around 60 cubic feet of high-level waste produced each year from processing the spent fuel from each 1000 Mwe of nuclear power. Slide 24 shows the estimated volume of high-level solidified waste that could be produced if our projections of nuclear power growth are on target.

You may be interested in what isotopes cause the radioactivity in this high-level waste that would require it to be buried essentially forever in our time frame of reference. The principal long-lived isotopes in the solid waste are cesium-137, strontium-90, curium-244 and Pu-241. A table of the estimated annual quantities of these isotopes and spent fuel waste is shown in the Appendix. It would be nice if we could remove the long-lived fission products and put them to use in applications such as radioisotopic power generators - space heating and radiation processing. However, we do not see these applications growing for some time in the future at any rate that could economically justify separation of these fission products. Unless there would be some market for these wastes, the cost of removing them would become enormous and we then have the task of storing many megacuries of strontium-90, cesium-137, etc., safely somewhere until a market develops.

For example, with a half-life of 30 years, one megacurie of cesium-137 buried in 1970 would decay to one-tenth of a megacurie or 100,000 curies in 2070, 10,000 curies in 2170 and so on.

Last, we have some projections of requirements for space in salt mines for burial of these high-level wastes. This projection is also shown in the Appendix.

Summary

I hope these broad projections will be useful in assessing the scope of the various transportation operations that will have to develop to service the nuclear power industry as it grows in the future. Business opportunities are beginning to develop in non-nuclear areas such as container fabrication and special transportation services as well as in the established nuclear industry areas. It is expected that the major business opportunities will be in arranging for spent fuel transportation and in shipping cask design and fabrication.

The reprocessors generally include spent fuel shipping in the pricing of their services and we expect that they will be the principal market for casks and transportation services. This pattern has developed as a natural competitive feature of the reprocessing industry business practice. Whether they will purchase casks and handle transportation or whether this will be done by separate companies under contract to the reprocessor and perhaps eventually with the utility is yet to be determined. We do not expect the nuclear power utilities will want to purchase expensive shipping casks for their own limited use if the casks could not be utilized efficiently.

Other related services and products will also be required in increasing volumes to keep pace with the growing power industry. These include container testing services, instrumentation, health physics services, decontamination services, and safeguards related activities.

One last point I wish to make is that the combined efforts of all the cask designers and the transportation industry must be applied to innovate and build transportation systems capable of economically and safely moving spent fuel and radioactive wastes. I am confident that the private sector can meet this goal. It would be most unfortunate if this country should have to plan its future nuclear power economy in large part on a system based on routine over-weight truck shipments requiring state road commission approval on an individual shipment basis.

APPENDIX

REACTOR SPENT FUEL EXPECTED TO REQUIRE SHIPPING IN 1972 AND 1973

1972	Metric Tons Uranium
Rochester Gas & Electric	15
Indian Point #2	27
Point Beach #1	15
1973	
Robinson #2	22
Palisades	28
Milestone #1	25
Turkey Point #3	24
Oyster Creek #1	27
San Onofre #1	18
Point Beach #2	16
Rochester Gas & Elec.	15
Dresden II	42
Zion I	28

EST. ANNUAL REACTOR RESIN WASTE GENERATION AND BURIAL

Year	Cubic Feet	Dollars for Handling and Burial
1970	2,500	$ 125,000
1975	30,000	1,500,000
1980	75,000	3,750,000
1990	200,000	10,000,000

APPENDIX

ESTIMATED ANNUAL QUANTITIES OF PRINCIPAL FISSION PRODUCTS IN SPENT FUEL WASTE*

Isotope	Half-Life Years	Quantity - Megacuries 1970	1980	1990
Cesium - 137	30	5	320	880
Strontium - 90	28.9	4	227	550
Curium - 244	18.1	.13	7.4	18
Plutonium - 241	13	.03	1.7	10

PROJECTED REQUIREMENTS FOR SALT MINE SPACE FOR HIGH-LEVEL WASTE BURIAL*

	1980	1990	2000
Annual Volume (Million Cubic Feet)	0.08	2.2	3.2
Annual Acres	5.2	14	20
Cumulative Acres	22	104	320

AVAILABILITY OF SPENT FUEL SHIPPING CONTAINERS FOR POWER REACTOR FUELS **

Company	No. of Units	Cask Designation	Truck or Rail	Weight Lbs.
GE	3	Dresden	Truck	45,000
	3	#15140	Truck	55,000
ATCOR	2	VDBG	Truck	67,000
NFS	1	Stanray	Rail	150,000
	1	Multiple Use Cask #100	Rail	120,000
Westinghouse	1	Yankee	Rail	150,000
Yankee Atomic	1	Yankee	Truck	44,000

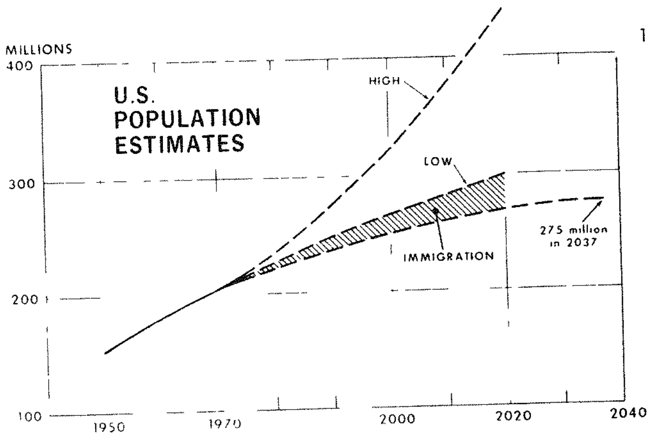
*ORNL - 4451, "Siting of Fuel Reprocessing Plants and Waste Management Facilities"

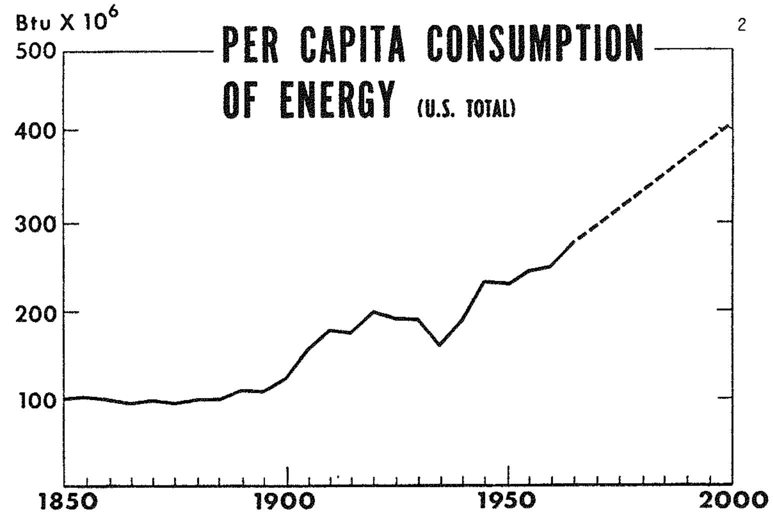
**"The Nuclear Industry - 1970"

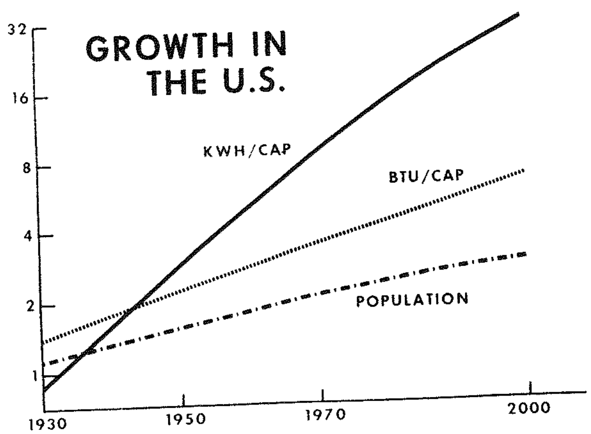
APPENDIX

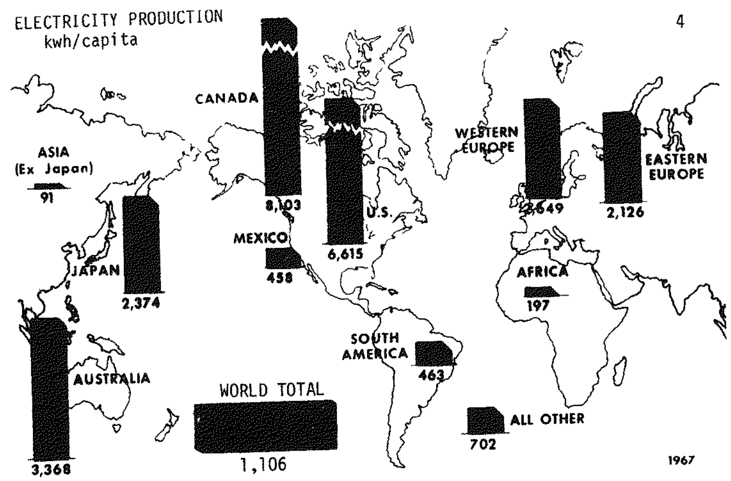
SPENT FUEL SHIPPING CASK DESIGN AND MANUFACTURING

Design, Licensing, And/Or Fabricate	Design & Licensing Only	Fabricate Only
ATCOR, Inc. Elmsford, New York	Hittman Associates Columbia, Maryland	P. F. Avery, Div. of Combustion Engineering Billerica, Massachusetts
National Lead Co. Albany, New York	Battelle Memorial Inst. Columbus, Ohio	Edward Lead-Allied Metal Co. Columbus, Ohio
Stearns-Roger Corp. Denver, Colorado	Westinghouse Electric Corp. Pittsburgh, Pa.	O. G. Kelly Corp. (A subsidiary of Cambridge Nuclear Corp.) Boston, Massachusetts
KPA Nuclear Inc. Pittsburgh, Pa.	General Electric San Jose, California	Pittsburgh-Des Moines Steel Co. Pittsburgh, Pa.
Nuclear Materials Services Pittsburgh, Pa.	NUS Corporation Rockville, Maryland	Whitehead & Kales Co. Detroit, Michigan
		Aerojet-General Fullerton, California


1
U.S. POPULATION ESTIMATES
MILLIONS
400
300
200
100
HIGH
LOW
IMMIGRATION
275 million in 2037
1950
1970
2000
2020
2040


2
PER CAPITA CONSUMPTION OF ENERGY (U.S. TOTAL)
Btu X 10^6
500
400
300
200
100
1850
1900
1950
2000


3
GROWTH IN THE U.S.
32
16
8
4
2
1
KWH/CAP
BTU/CAP
POPULATION
1930
1950
1970
2000


4
ELECTRICITY PRODUCTION
kwh/capita
CANADA
8,103
U.S.
6,615
MEXICO
458
ASIA
(Ex Japan)
91
JAPAN
2,374
AUSTRALIA
3,368
WORLD TOTAL
1,106
SOUTH AMERICA
463
WESTERN EUROPE
2,649
EASTERN EUROPE
2,126
AFRICA
197
ALL OTHER
702
1967

ENERGY RESERVES 5

GAS and OIL .... 30 YEARS

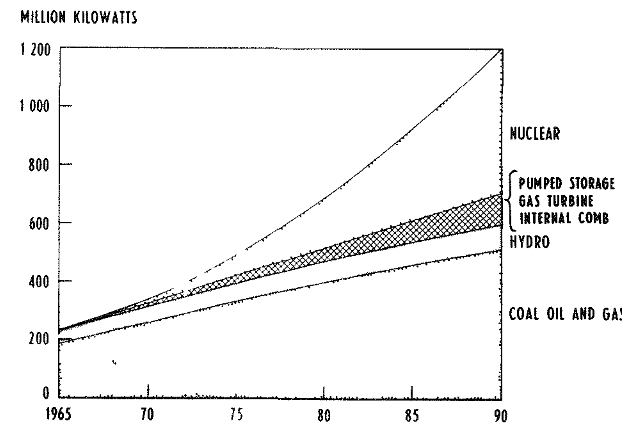
COAL .... 80 YEARS

URANIUM & THORIUM
- IN WATER REACTORS ...... 40 YEARS
- IN BREEDER REACTORS ... 1,000 YEARS

TRITIUM
- IN FUSION REACTORS ...... MILLIONS of YEARS

ELECTRIC GENERATING CAPACITY 6

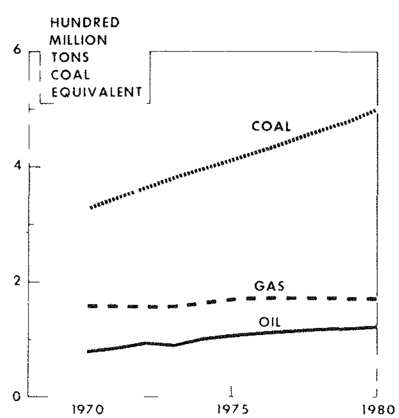
IN THE UNITED STATES



ELECTRIC UTILITY FOSSIL FUEL USE

KEYSTONE FORECAST

7



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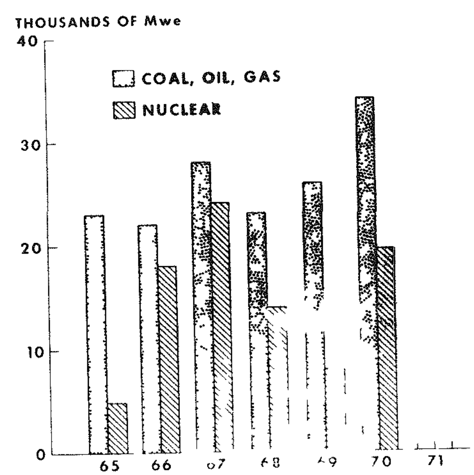


SOURCE EEI

ORDERS

FOR STEAM SUPPLY SYSTEMS

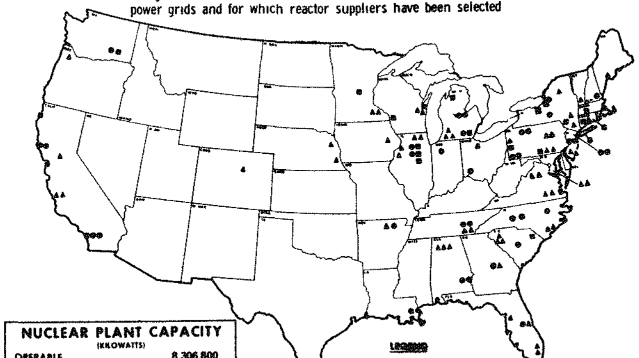
GROWTH OF NUCLEAR POWER 9

			NO.	Mwe
UNITS OPERATING DEC. 1968			12	2,814
STARTING UP IN 1969	OYSTER CREEK	530		
	NINE MILE PT.	500		
	ROBT. E. GINNA	420	3	1,450
STARTING UP IN 1970	DRESDEN 2	809		
	ROBINSON 2	700		
	PT. BEACH 1	497		
	MILLSTONE 1	652	4	2,658
SCHEDULED FOR START UP IN 1971			11	7,674
			30	14,596

OCTOBER 1970

NUCLEAR POWER PLANTS IN THE UNITED STATES 10

The nuclear power plants included in this map are ones whose power is being transmitted or is scheduled to be transmitted over utility electric power grids and for which reactor suppliers have been selected



NUCLEAR PLANT CAPACITY (KILOWATTS)

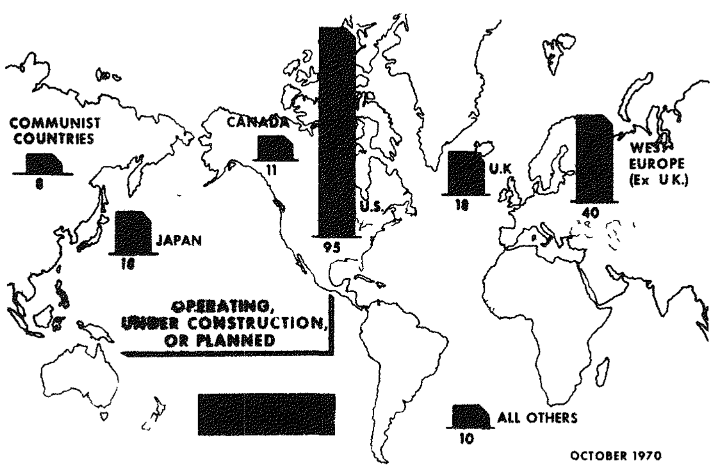
OPERABLE	8 306,800
BEING BUILT	47 102 000
PLANNED REACTORS ORDERED	36 727 000
TOTAL	92 136,800

TOTAL ELECTRIC UTILITY CAPACITY AS OF JANUARY 31 1971 340 718 926 KILOWATTS

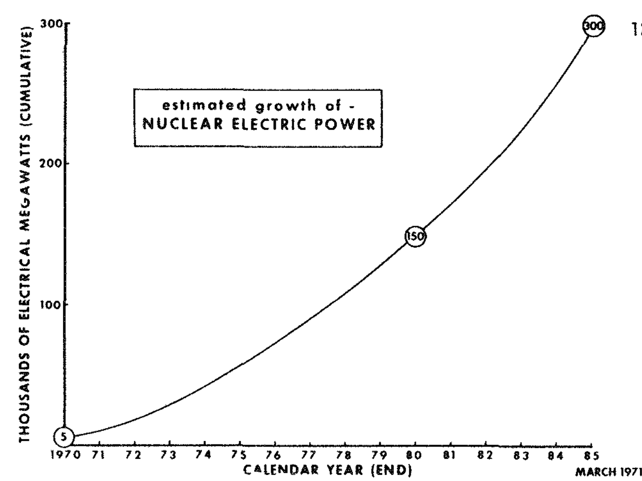
(over)

U S Atomic Energy Commission
March 31 1971

NUCLEAR ELECTRIC GENERATING CAPACITY 11
MILLION KILOWATTS



OCTOBER 1970



MARCH 1971

ELECTRIC POWER-
COST COMPARISONS

13

FUEL	PLANT SIZE Mwe	AVG. PLANT COST $/KW	BREAK EVEN FUEL COST ¢/MILLION BTU
GAS	600	95-120	45-50
OIL	600	140-180	30-40
COAL	1,000	180-210	25-35
NUCLEAR	1,100	230-260	16

OCTOBER 1970

These figures reflect a sampling of data gathered through discussions with various electric utilities and architect-engineers.

These figures will vary widely among utilities depending on geographic location, labor cost and productivity, and other factors.

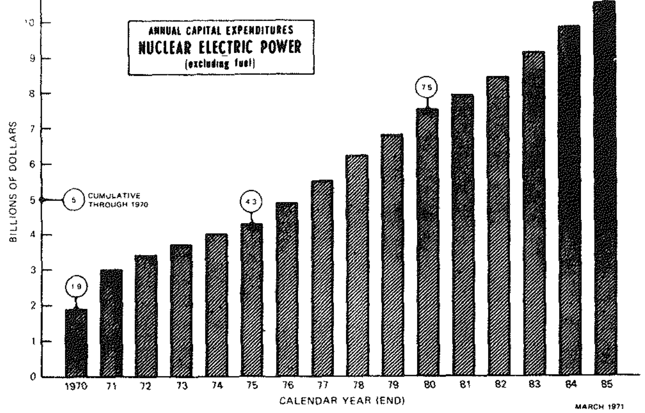
Figures for fossil plants will also vary depending on costs associated with meeting air pollution requirements.

The break even fuel costs are based on nuclear fuel costs at 16¢/million Btu levelized over a 16 year period.

The break even costs shown for fossil fuels are applicable only where long-term contracts for these fuels are available.

Data are for plants expected to become operational in the 1975-76 period and include allowances for escalation and interest on construction.

14



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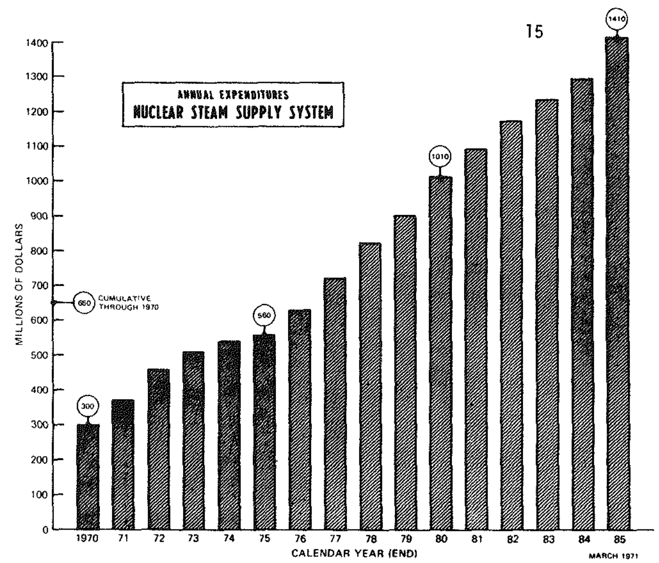

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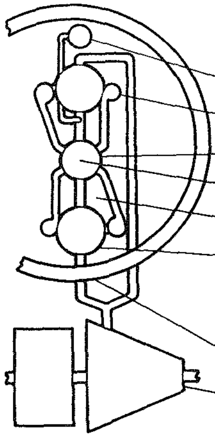
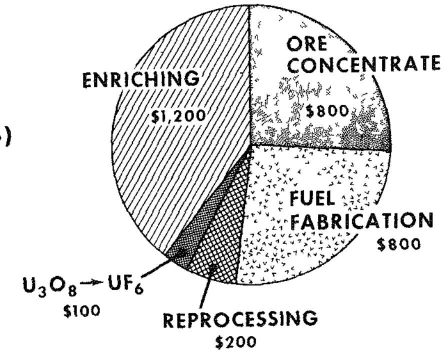


MAJOR COMPONENTS	1985 EXPENDITURES (million $)
PRESSURIZERS	15
PUMPS	70
PRESSURE VESSELS	210
I&C, RODS & DRIVES	300
VALVES, PIPES, TANKS	210
STEAM GENERATORS	220
NSSS TOTAL	$1.4 BILLION
CONTAINMENT	240
TURBINE-GENERATORS	1,200

NUCLEAR ELECTRIC POWER 17

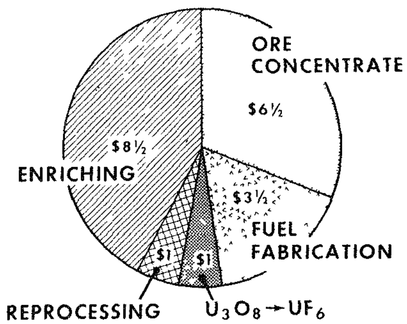
FUEL CYCLE COSTS (MILLIONS)

1985



NUCLEAR ELECTRIC POWER FUEL CYCLE COSTS (BILLIONS) 18

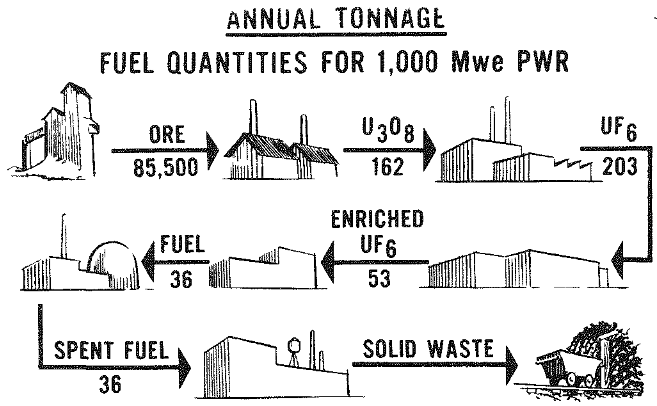
CUMULATIVE THROUGH 1985



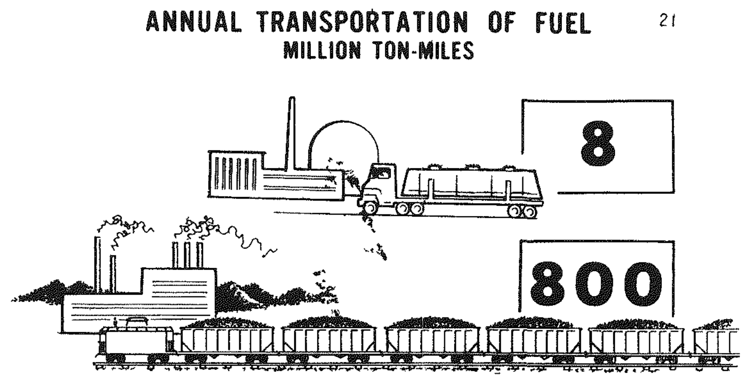
NUCLEAR ELECTRIC POWER 19

CUMULATIVE EXPENDITURES THROUGH 1985

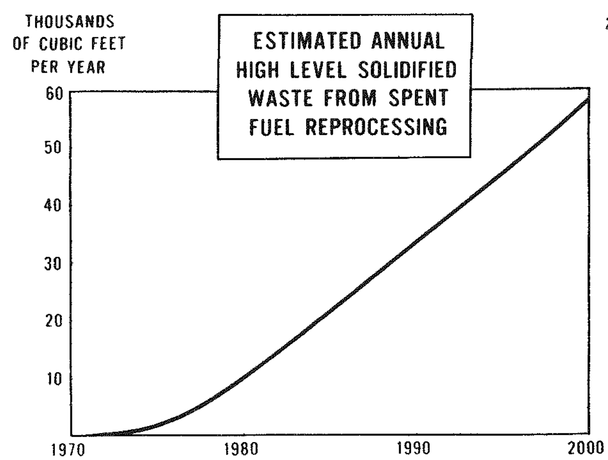
- PLANT CONSTRUCTION $100 BILLION
- FUEL CYCLE COSTS $23 BILLION


ANNUAL TONNAGE
FUEL QUANTITIES FOR 1,000 Mwe PWR
ORE
85,500
U_3O_8
162
UF_6
203
ENRICHED
UF_6
53
FUEL
36
SPENT FUEL
36
SOLID WASTE

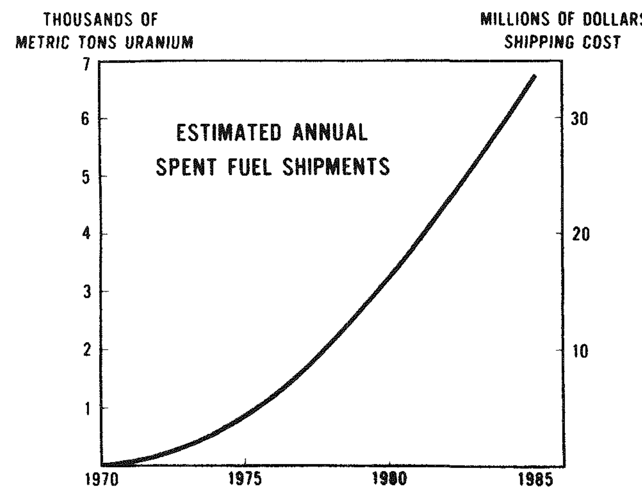
21


ANNUAL TRANSPORTATION OF FUEL
MILLION TON-MILES
8
800

22


THOUSANDS
OF CUBIC FEET
PER YEAR
ESTIMATED ANNUAL
HIGH LEVEL SOLIDIFIED
WASTE FROM SPENT
FUEL REPROCESSING
60
50
40
30
20
10
1970
1980
1990
2000

23


THOUSANDS OF
METRIC TONS URANIUM
MILLIONS OF DOLLARS
SHIPPING COST
ESTIMATED ANNUAL
SPENT FUEL SHIPMENTS
7
6
5
4
3
2
1
30
20
10
1970
1975
1980
1985

TRANSPORTATION SAFEGUARDS

Remarks by Delmar L. Crowson
Director, Office of Safeguards and Materials Management, USAEC
Presented at
Third International Symposium
on Packaging and Transportation of Radioactive Material
Richland, Washington
August 16, 1971

Introduction

When the new Office of Safeguards and Materials Management was established on July 1, 1967, with the mission of developing safeguards policy and a supporting safeguards research and development program, the very first thing we did was examine the entire nuclear fuel cycle to determine where efforts should be concentrated to bring safeguards up to an acceptable level on a fairly uniform basis throughout the cycle. It became clear at the outset that the weakest link in safeguards was probably during the transportation phase for special nuclear materials. As a consequence, and with the very able assistance of the AEC Transportation Branch, then in the Division of Construction, we initiated a study of the problem to identify possible solutions. We arranged a meeting with representatives of the transportation industry and those officials from AEC who had an interest in transportation and safeguards programs to explore the nature of the problem and possible solutions. That first meeting with industry on transportation safeguards was held in July of 1968 (a second meeting was held in October of 1969). At the time of the second meeting, the Commission had already experienced several misroutings, one of which involved significant quantities of strategically important nuclear materials which could not be accounted for for about a week. Although by that time the transportation industry in the U. S. was experiencing a burgeoning situation with respect to theft of other goods from the transportation cycle, one result of the first meeting was a request by many of the transportation industry representatives to give them an opportunity to clean up the problem of theft themselves without government interference. Notwithstanding, our Office continued to study the problem, as we are continuing to study it today, and we identified several alternative solutions which are discussed together with their status and our views in the following paragraphs.

Exclusive Use of Vehicle

Since our misrouting experience invariably involved shipments of less than full vehicle load quantities, one immediate possibility presenting itself was the establishment of a requirement for exclusive use of vehicles. We believed that exclusive use of vehicles would improve the situation considerably, since under that system the material would remain in the transportation phase for a much shorter period than otherwise, and the vehicle presumably would not be subject to offloading and reloading a number of times at a point where inadvertent misrouting and exposure to theft and diversion are easier. However, it became apparent very early that those concerned with shipping the material would have serious objections to a requirement to specify exclusive use of vehicle since the costs of such shipments would, they told us, be very high. The obvious question was why can't shippers who normally ship less than full load quantities allow shipments to accumulate until they have full vehicle loads and thereby reduce the company burden commensurately. The rebuttal to this was fast and clear. Fully enriched uranium-235 involves a capital outlay of about $10,000 a kilogram. Allowing shipments to accumulate for any extended period of time, as would be involved in waiting for full vehicle load quantities, would involve heavy capital investments by the shippers for material not being actively used in the shippers' program, and again the economic factor posed a serious problem. Finally, through our contacts with the industry, and those highly qualified in understanding the criminal threat, we learned that in many instances vehicle cargoes are hijacked after some degree of collusion on the part of those people in the transportation industry who either drive the vehicles or otherwise control the material at terminals and we found that even specifying exclusive use would not necessarily provide a high degree of protection against hijackings, since obviously a potential hijacker interested in this cargo need not settle for a less than vehicle load shipment to carry out his activity. In fact, a larger shipment in an exclusive use environment might better serve the potential hijacker's purpose since it would provide him with a more lucrative target.

Access Authorization

One of the possible solutions to this dilemma was to provide for an access authorization for drivers and cargo handlers based on a screening process which might eliminate the high risk individuals. On exploring this avenue, we soon discovered that the Atomic Energy Act would have to be amended to provide for access authorization, and, additionally, the concerned common carriers would possibly have to submit, for access authorization, virtually all their employees to ensure that when they had a shipment requiring access authorization, appropriately authorized individuals would be readily available. To date, we have taken steps to submit proposed legislation enabling the application of an access authorization program, but we have not yet fully determined the extent to which the access authorization program might effectively be used in the transportation cycle. Once again, it was quickly brought to our attention that even having an access authorization program in effect in transportation would not provide a high degree of assurance that cargoes under safeguards would not be hijacked, since a study of the past industry experience with hijacking revealed that a significant number of hijackings appeared to have involved collusion, but certainly not all of them. We concluded that calling for exclusive use and access authorized drivers and handlers would not provide absolute assurance that the cargo was adequately safeguarded and such requirements might be impractical.

Constant Surveillance

The next thing we explored was the possibility of requiring that material in transit be under constant surveillance of an independent party, such as a government guard or a guard hired for that purpose by the shipper. Exercising the constant surveillance requirement would provide a reasonable degree of protection against both collusion-type theft and hijacking and even unsophisticated efforts by independent hijackers since presumably the guard could be armed and trained to deal effectively with these situations. Our consideration of this alternative also led to an early conclusion that the cost would be very high. Additionally, while it did appear that using a guard for an escort might be effective against certain kinds of theft effort, it would not be effective against theft such as might be expected from a highly organized crime syndicate or even a carefully planned theft by a violence-oriented extremist group, both of which could be reasonably expected to place adequate resources on the mission to overcome the protection capabilities of a single armed guard.

Convoys

The obvious next step was to consider the feasibility of requiring that all movements of strategic quantities and types of special nuclear materials be made by armed convoy where a force of several men, probably armed, would move along with the vehicle under safeguards. It was recognized that such a group could conceivably be effective in preventing many kinds of thefts and eliminate all but the most sophisticated hijacking efforts from the realm of feasibility. It did not take long for our consideration to reveal that the cost of such a requirement would be much higher than any of the other alternatives.

Monitors

Finally, it was concluded that an effective practical system had to have most of the features previously discussed for appreciable safeguards benefits to accrue but had to avoid excessively high cost impacts. Thus, some forms of exclusive use, access authorized drivers, and armed guards, and some use of some form of limited escort was required. We learned that the material was most vulnerable to theft and diversion during those periods it was subject to being handled, that is, removed from a vehicle and placed in a terminal for a finite period of time or removed from a terminal and placed in a vehicle (terminal in this case being an enroute terminal where the material is temporarily stored awaiting further transportation). This was also the point at which some misroutings occurred.. This led us to the conclusion that limited escort, or what we later called monitors, during scheduled handling periods was within the realm of economic practicability and did provide a new and reasonable degree of protection.

Hand-to-Hand Signature Service

We had earlier specified hand-to-hand signature service on the grounds that it was economically practical and many carriers who offered such services described it in terms that led us to believe that it could provide a high degree of safeguards through constant surveillance, etc. As you probably know, before we decided to consider imposing the monitor on top of the hand-to-hand signature requirements, we had run covert inspections and discovered first hand what many observers had told us; namely, that signature service does not now work effectively as a safeguard, and more importantly, that at the operating level in most of the transportation companies involved, their specified procedures are not carried out. We found out that this lack of following procedures led to misroutings and delays in shipments.

Data Base for Possible Inventory Regulation

While we were examining these alternatives to upgrade safeguards in transportation, we entered into a contract with the Edlow International Company to conduct a factual study of special nuclear material shipping patterns of U. S. commercial organizations and of unclassified exports by the AEC and its contractors. As a base, we used shipments of 5 kilograms plutonium or U-233 or 5 kilograms of U-235 in enrichments of greater than 20%. We had to know precisely how many of these kinds of shipments per year are involved, what quantity and type of material moved in each of these shipments, how are the shipments made, and how many days do the shipments remain in transportation. We had to know not only for the current time frame, but we needed projections for the future. The report of the Edlow International Company was completed on May 1, 1971. I believe the results will prove to be of great value in our further consideration of necessary measures in transportation safeguards.

For example, we learned that several shipments were in transportation for as long as 10 to 20 days. In many instances, the shipper who released the shipment in the first case had no idea how long the material would remain in transportation. Finally, we learned with respect to our proposed policy for monitors that 2,270 transfers (involving approximately 67 cities of the U. S.) took place in FY 1970 which would be subject to monitoring and that the cost to shippers for monitoring by the use of available private detective agency personnel for the task would be in the order of one quarter million dollars total per year. This estimate of one quarter million dollars would cover the cost of monitoring as well as the additional (administrative) costs of rigid control of movements and notifications to the monitoring agency.

Some Anticipated Advantages from Monitoring Requirements

Some critics of the proposed monitoring program have noted that monitors at the scheduled transfer points could not be expected to prevent theft or hijacking. While I agree that the role of the monitor would simply be to observe and not influence the handling of shipments, his presence would deter certain kinds of threats. Additionally, the requirement for the use of monitors would serve as an impetus for shippers to carefully pre-plan their shipments which they would be motivated to do as a means of reducing the cost of providing monitors. It would also influence them to continually remain in touch with their shipment in order to effectively control their application of monitoring. Both of these measures would have a benefit to the safeguards objectives and should result in totally eliminating situations where material would remain in the transportation cycle 10 to 20 days and then without the prior knowledge of the shipper.

USAEC Regulation of the Transportation of Nuclear Materials

There are those who hold that the most practical means of securing appropriate physical protection for shipments is through Government regulation of the carriers, specialized contract carriers or a Government transport corporation perhaps using a preponderance of military airlift.

In examining each of these alternatives for safeguards effectiveness, the primary questions are: will they prevent hijacking; will you know when and where the theft happened; and can an effective recovery effort be mounted with reasonable assurance of recovery?

These questions presume that you can specify in regulations, contracts or operational doctrines and procedures the conditions to be met, that adequate service will be available to the nuclear industry and that there are sufficient Government resources available to inspect and enforce the conditions.

In analyzing these alternatives or combinations we cannot foresee any system short of a large armed convoy that will prevent hijacking. Even then, if the stakes are high enough, attempts might be made. Perhaps the target might shift back to the storage sites for the material.

Secondly, will you know when and where it happened? At present, some carriers have six-hour call-in times; others have two-way radios. So, one's judgment of this aspect comes out a conditional maybe. We will say more about the prospects in this area.

Thirdly, the effectiveness of the recovery effort -- at present we would expect the cooperation of the FBI and other federal, local and state authorities. The recovery question is one of time. We believe that if more than 12 hours elapse from the time of disappearance that you may recover the carrier, but not the contents.

To accomplish these alternatives we would have to recruit expert staff, write and promulgate regulations, and agree upon operational conditions. To get implementation will take time and diligent effort. Obviously, much has been done to date, but the final product is not so close at hand. Therefore, we believe we must institute other measures immediately.

Discussion of Alternatives

We wish to make our point very clear. We do not consider that exclusive use of vehicle, access authorization, constant surveillance, convoys or monitors have no safeguards value. On the contrary, we think that they all do, and even though some of them carry with them the significant burden of cost, we recognize that in the interest of safeguards, many are worthy of implementation. We also consider that the marginal advantages to safeguards from all of the methods discussed (except convoys) are not sufficiently great, and, therefore, we have opted for, on a practical basis, the use of monitors as solving two of our major problems -- misrouting and deterrence of thefts at transfer points. However, we believe as noted before that the most effective system from a safeguards standpoint would be a system which involved a convoy so that a hijacking countermeasure in the form of a response force could be at the scene of the attempted hijacking in time to be potentially effective. We believe, however, that we can effectively approach this capability without requiring armed convoys.

Constant Communication and Local Response Force Capability

One step toward achieving an effective response capability would be to have a constant communication with the vehicles carrying safeguarded cargoes. This communication could be in a form which involves feeding all the prerouting information into a computer which might then continually interrogate the vehicle and compare the location and movement response with the schedule. Any observed diversion from prerouting could then sound an alarm and by the advanced training of and use of local police authorities, a response force could be dispatched to the scene of the suspected trouble immediately.

This capability, of course, will not come easy but we have already made a real start. Later this year, a test of a constant communication system using synchronous satellite relay will be made. We have already talked to some local police authorities and they are enthusiastic about developing the capability to assist us in responding to alarms. We have directed our contractor at Argonne, who runs our safeguards training program, to develop a program to train police authorities.

Graded Safeguards

At this point, one might reasonably ask do all shipments of nuclear material, regardless of type, quantity and form, deserve the same degree of physical protection. Actually, we in the safeguards business in AEC have enthusiastically embraced the concept of graded safeguards. What we mean by graded safeguards is that the materials would be categorized into separate groupings which would be a function of the quantities, type and form of material, the environment in which it is placed and the threat against which the material must be protected. Then we would establish a set of requirements for safeguarding each grouping so that we end up with an overall constant level of safeguards. We believe this concept will apply to transportation as well as to the use and storage environments. As a consequence, we envision that the monitor requirement, together with the hand-to-hand signature service and the communication and response capability, would be applicable to the bulk of private industry shipments, but that certain shipments would continue to require continual escorts, and others would continue to require convoys.

Conclusions

Although we have had misroutings, we have had no known cases of hijacking or theft of special nuclear material from transport. Therefore, it is our conclusion that the immediate application of the monitor program published in the Federal Register on February 3, 1971, as an amendment to 10 CFR 73, together with the successful development of constant communications and the further development of response force capabilities will provide a needed degree of upgrading of transportation safeguards.

This action could perhaps be paralleled by use of Government contractor specialized carriers using both land and air forms of transportation to provide experience data as to adequacy of service and costs. This experience should lead to a more definite conclusion as to the form of Government regulation, inspection and effective enforcement.

THE AEC ACCIDENT RECORD AND RECENT CHANGES IN AEC MANUAL CHAPTER 0529

W. C. Mc Cluggage

ABSTRACT

The transport of goods of any kind must be done in a way that is safe: Safe in the sense that persons who may come into contact with the goods will suffer no harm; safe in the sense that no damage will be done to the material being shipped or to property with which it comes into contact. Our area of interest here, however, is confined to the safe packaging and transporting of radioactive materials including those that are fissionable. To accomplish our purpose a very comprehensive array of rules and standards has been developed. These are found in the appropriate Department of Transportation, International Atomic Energy Agency, and the United States Atomic Energy Commission regulations. The packaging regulations also appear in AECM 0529 "Safety Standards for the Packaging of Radioactive and Fissile Materials." The success of these regulations and the practices and procedures stemming from them was clearly indicated by D. E. Patterson in his paper on accident experiences, given 2 years ago at the second meeting of this kind. Mr. Patterson presented at that time a comprehensive analysis of transportation accidents and

predicted future trends. We have studied the accidents of the intervening 2 years and have found that the analysis and the predictions are fundamentally sound. To assure continuance of the fine record established thus far, it is essential that the regulations and standards be constantly revised and improved. Recent changes are reflected as revisions to AECM 0529.

Perhaps the most significant revision stemming from changes in regulations is that one which sets forth the requirement that AEC must prepare or have prepared, and review, suitable safety evaluations for Type B packaging. Such evaluations in the past were reviewed by the DOT. The AEC will perform this function in the future. Other revisions in AECM 0529 include changes in the so-called "exemption" clause, and the addition of guidance statements regarding shipping containers for radioactive and fissile materials.

ACCIDENT EXPERIENCE

For the period 1957 through 1964, the AEC's experience with transportation accidents involving radioactive materials is recorded in TID 16764 and supplements 1 and 2, "A Summary of Incidents Involving USAEC Shipment of Radioactive Material." A previous document AECU 3613, "A Summary of Transportation Incidents in Atomic Energy Activities, 1949-1956," reviewed earlier experience. These documents may all be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., 20412.

At the Second International Symposium held in Gatlinburg, Tennessee, in 1968, Mr. D. E. Patterson of the AEC gave a paper summarizing the accident experience of the AEC in the shipment of radioactive materials. In his treatment of the subject, Mr. Patterson's classification of the incidents follows a method suggested by Morgan, Knapp, and Thompson of John Hopkins University in their paper, "A Study of the Possible Consequences and Costs of Accidents in Transportation of High Level Radioactive Material." This scheme is based upon the extent of radioactive material release and it is as follows:

Class I Radiation Release. The vehicle has been involved in an accident or package damage is suspected. The shipment is delayed or stopped. No radioactive material is released and there is actually no loss of integrity to the package.

Class II Radiation Release. The package integrity is breached. However, there is no release of radioactive materials.

Class III Radiation Release. Radioactive material is released from the package but is confined to the vehicle.

Class IV Radiation Release. Radioactive material is released to the ground or trafficway with no runoff or aerial dispersal.

Class V Radiation Release. Radioactive material is released, resulting in aerial dispersal.

3

Class VI Radiation Release. Radioactive material is released and enters a watercourse, either directly or after spilling to the ground or trafficway.

This system of classification is well suited to our use since all the pertinent incidents fit into one of the six classes, and it represents a good approach to describing radioactive material releases according to the potential consequences. These advantages were quite thoroughly presented in Mr. Patterson's paper. Hence, I will confine my remarks to the incidents that have occurred during the period 1968 through 1970. During that period there have been 29 reported incidents. These are shown in Table 1 relative to previous years:

Table 1

Incidents Experienced by Year

Year	No. of Incidents	Year	No. of Incidents
1949	1	1960	12
1950	1	1961	9
1951	1	1962	14
1952	2	1963	9
1953	0	1964	15
1954	1	1965	18
1955	2	1966	6
1956	5	1967	6
1957	6	1968	11
1958	5	1969	13
1959	15	1970	6

Additional comparisons with previous years are shown in tables 2, 3, and 4 for "Incident Experience by Class of Radiation Release; Incident Experience by Type Irrespective of Transport Mode; and Incident Experience by Type of Material Involved."

Table 2

Incident Experienced by Class of Radiation Release

No. of Incidents

Class	1968-1970	1965-1967	1963-1964	1962	1957-1961	1949-1956
I	15	18	12	9	29	6
II	5	6	1	1	7	2
III	4	4	6	2	7	0
IV	5	4	5	2	3	3
V	1	0	0	0	1	1
VI	0	0	0	0	0	1
TOTAL	30	32	24	14	47	13

Table 3

Incident Experience by Type - Irrespective of Transport Mode (Unless Specified)

Type	1968 1970	1965 1967	1963 1964	1962	1957 1961	1949 1956
Handling	15	6	2	1	15	0
Impact (Collision-Truck)	5	13	10	4	10	7
Impact (Collision-Air)	1	0	0	0	0	1
Impact (Collision-Rail)	0	1	0	1	2	0
Fire	1	1	0	2	5	3
Vehicle or Equipment Failure	0	0	1	0	5	0
Leakage of Containers	5	7	5	3	4	0
Derailment	1	1	1	2	3	2
Tiedown of Bracing Failure	0	0	4	1	2	0
Aerial Dispersal	0	0	0	0	1	0
Packaging Failure	2	3	1	0	0	0

Table 4

Incident Experience by Type of Material Involved

Type of Materials	1968 1969	1965 1967	1963 1964	1962	1957 1961	1949 1956
	No. of Incidents					
Source Material	3	2	13	8	14	10
Radioisotopes	12	16	3	1	10	0
Irradiated Fuel El.	1	1	2	1	8	1
Special Nuclear Material	5	7	1	3	4	0
Radioactive Waste	6	0	1	1	3	0
Empty Containers	0	0	1	0	3	0
Contaminated Mach.	0	0	2	0	2	2
Unknown	3	6	2	0	2	2

In his report 2 years ago Mr. Patterson, by use of a relationship between the class of radioactive material release and relative occurrence for each class, see figure 1, attempted to project future experience. His projections are shown to be very good for the period 1968 through 1970. The curve shown in figure 1 represents very well the experience for these years.

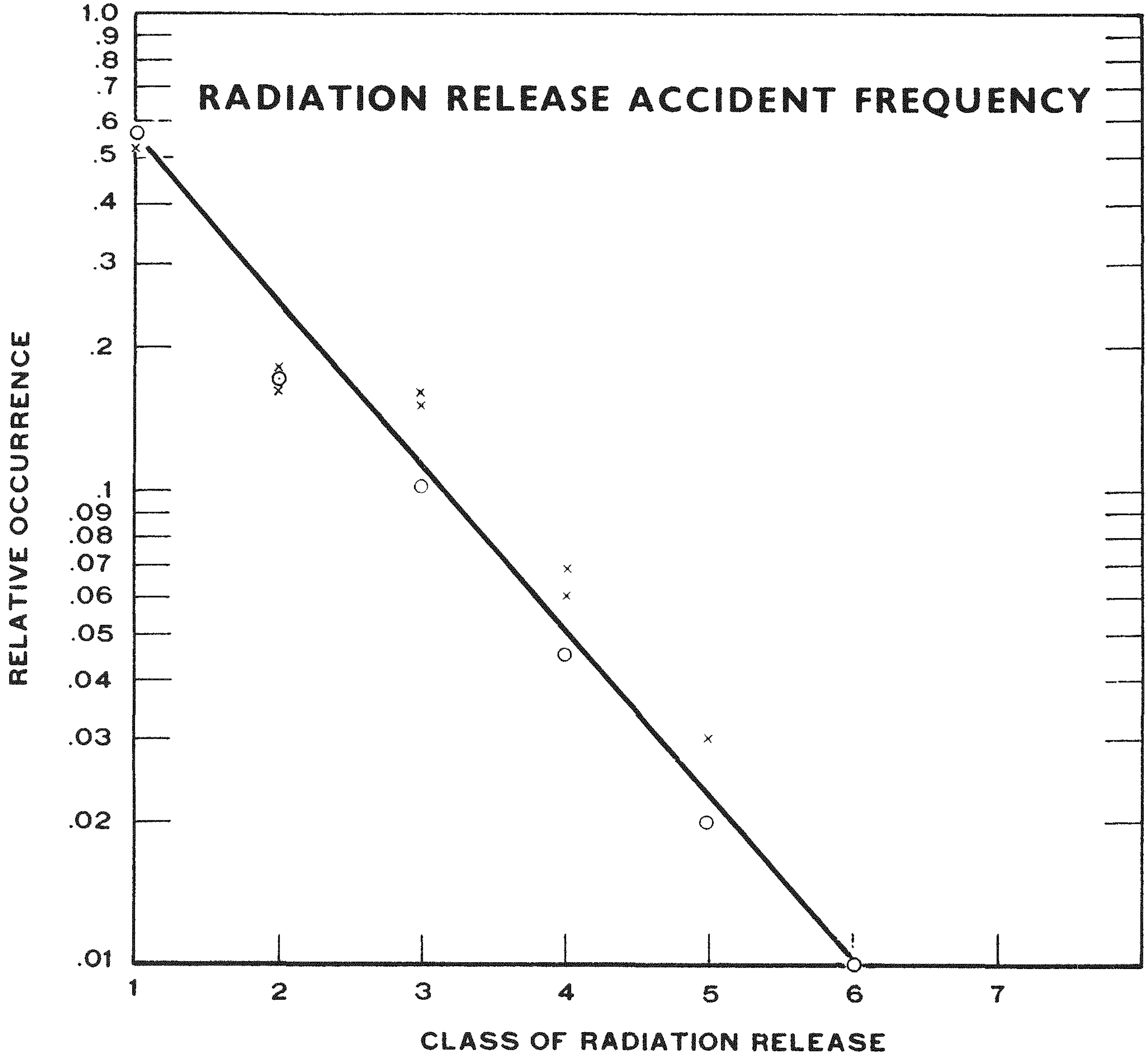


Figure 1. Frequency of Occurrence of Accidents Based on Class of Radiation Release

Based upon these observations and our additional experience, it is quite appropriate to summarize this part of this paper with a modified version of the abstract from Mr. Patterson's Gatlinburg paper.

> "U. S. Atomic Energy Commission (AEC) contractors have been shippers of radioactive materials for more than 23 years. Since 1949, a record has been accumulated of transportation accidents which have involved these shipments. Based on an analysis of this experience, it is predicted that, during the near future, accidents can be expected at a rate of 30 per year. However, it is expected that in eight accidents only will the material be released from the package and that in three accidents only will the material escape beyond the confinement of the vehicle."

AEC Manual Chapter 0529

The Atomic Energy Commission's Manual Chapter 0529, "Safety Standards for the Packaging of Radioactive and Fissile Materials," and related regulations have a direct influence on the consequences of accidents wherein radioactive materials are involved. For this reason we feel that it is appropriate to mention at this time the changes and proposed changes in the chapter. These changes are made as a result of changes in DOT, IAEA and AEC regulations or because of changes required by the General Manager. This chapter was first issued in 1964. Its stated objective was:

> "To establish procedures and packaging standards for preparing radioactive and fissile materials for transportation."

While it was generally understood that Manual Chapters applied only to operations done directly by AEC personnel or by AEC contractors, the original version of AECM 0529 was not completely clear on this. The statement of objective as revised in the August 1966 version clarified the point. The objective was reworded:

> "To establish standards for the packaging of fissile materials or large quantities of radioactive material for transportation from facilities not subject to 10 CFR Part 71 and to establish responsibilities for issuing AEC certificates of approval for such packages."

This first revision to AECM 0529 was issued concurrent with the initial publication of a new 10 CFR Part 71 in the AEC regulations. This part is entitled "Packaging of Radioactive Materials for Transport." The packaging standards in both these issuances are identical. Those of you who are familiar with these two items will recall that the revised AECM 0529 was a great improvement over the initial document.

The second revision of AECM 0529 (the current version) was issued February 15, 1969. The significant changes in the chapter were the following:

"1. Under 0529-03, 'Responsibilities and Authorities,' subsection 032 were revised to include the Division of Technical Information, and the Manager, Space Nuclear Propulsion Office.

"2. Under 0529-05, 'Basic Requirements,' a new subsection 054 was added citing the IAEA requirements that must be met.

"3. Changes were made in both the definitions and exemptions set forth in the appendix, part I.

"4. The principal change reflected a change in the DOT regulations which directly affects shippers of fissile materials. The previous limit of 40 radiation units established to control Fissile Class II shipments is changed to a maximum transport index of 50 in a single vehicle or storage area (see appendix, part II, I.2.). The new transport index number to be placed on existing packages may be determined by increasing the existing radiation unit value thereon by the factor 1.25."

In keeping with the requirement that the standards for packaging radioactive material for transport be the same throughout the AEC controlled operations, this revision was issued simultaneously with the first revision of 10 CFR Part 71.

Turning to recent changes in AECM 0529, we note that these are of two kinds. Those that stem from changes in regulations and those that stem from changes in AEC contractor operations.

The most significant change is the one involving approvals for type B packagings. At DOT's request the AEC revised its regulations and Manual Chapter to include approval requirements and procedures for the type B category. This change had the effect of adding to AECM 0529 standards and requirements for AEC approval of type B packages and describing the procedures for obtaining AEC approval of type B as well as large quantity and fissile material packagings.

The provisions of AECM 0529, first revision, in effect since August 1966, required AEC contractors who wish to ship fissile material or large quantities of byproduct, source, or special nuclear material to apply to the DOT for a special permit after indicating AEC approval of the type of package to be used. The changes in the current version of AECM 0529 require AEC contractors to certify that packages to be used to deliver to a carrier, type B quantities of radioactive materials, meet the requirements set forth in the DOT regulations before the AEC will issue the necessary approval.

That the approval may be (1) a license (either specific or general) or license amendment issued under 10 CFR 71, (2) an administrative approval issued to AEC contractors by AEC Field Offices in accordance with standards and procedures published in the AEC Manual, or (3) an approval issued by the AEC's Division of Materials Licensing to persons under DOT jurisdiction who are not AEC licensees. The latter category of non-AEC licensees includes, for example, licensees in Agreement States and radium shippers in non-Agreement States who wish to ship Type B or large quantities of radioactive material.

To obtain AEC approval of a particular packaging for Type B, large quantity, or fissile materials a contractor must evaluate the proposed packaging against the DOT requirements and then assure the appropriate Field Office that these requirements have been met. The contractor's evaluations are then reviewed by the Field Office staff and, if found satisfactory, a certificate of AEC approval is granted by the AEC. The proposed packaging is then available for use by the AEC and its contractors. The necessary contents of the contractor's evaluation submitted to the Field Office are as follows:

A. Package Description

The evaluation shall include a description of the proposed package in sufficient detail to identify the package accurately and to provide a sufficient basis for evaluation of the packaging. The description should include:

1. The Packaging

   a. gross weight

   b. model number

   c. specific material of construction, weights, dimensions, and fabrication methods of:

      (1) receptacles, identifying the one which is considered to be the containment vessel;

      (2) materials specifically used as nonfissile neutron absorbers or moderators;

      (3) internal and external structures supporting or protecting receptacles;

      (4) valves, sampling parts, lifting devices, and tie-down devices;

      (5) structural and mechanical means for the transfer and dissipation of heat; and

   d. identification and volume of any coolants and of receptacles containing coolant.

2. The Package Contents

   a. identification and maximum radioactivity of radioactive constituents;

   b. identification and maximum quantities of fissile constituents;

   c. chemical and physical form;

   d. extent of reflection, the amount and identity of nonfissile neutron absorbers in the fissile constituents, and the atomic ratio of moderator to fissile constituents;

   e. maximum weight; and

   f. maximum amount of decay heat.

B. Package Evaluation

The contractor must prepare a package evaluation that meets the requirements set forth in AEC Appendix 0529.

Other changes of a nonregulatory nature appearing in the current version of AECM 0529 are concerned with interpretation and operational matters. There is one of the former and three changes pertinent to operations. These are discussed in the following text.

Subparagraph c. of 0529-032 which is included in the chapter to provide flexibility at the Field Office level has, because of its present wording, led to misinterpretations and improper application. This subparagraph presently appears in AECM 0529 as follows:

"grant such exemptions from the standards set forth in appendix 0529 as they determine will not endanger life or property or the common defense and security, and within 30 days after granting an exemption, provide the Director, Division of Operational Safety, a detailed report of the reasons for granting it."

The original intent for this subparagraph was that it provide a way to safely package and ship material and items of equipment that could not readily be handled by rigid application of the existing regulations. Unfortunately, in its initial form it was interpreted as providing exemption from Department of Transportation regulations. To prevent further misunderstandings and to provide the intended meaning, the initial subparagraph c. in paragraph 032 of AECM 0529 was replaced by the following:

"grant such alternatives to the requirements set forth in appendix 0529 as they determine will provide equivalent protection of life or property and to the common defense and security; and within 30 days after granting an alternative, provide the Director, Division of Operational Safety, a detailed report of the reasons for granting it. The granting of such alternatives is in no way to be construed as the granting of exemptions or exceptions from or to Department of Transportation or other regulatory agency requirements."

There are three changes that affect the criteria for operations. These changes first appeared as an Immediate Action Directive (IAD) entitled "Guidance Statements Regarding Shipping Containers for Fissile and Other Radioactive Materials."

During recent surveys of procedures and practices in handling fissile and other radioactive materials, it was found that existing Manual Chapters pertinent to safety did not provide sufficient guidance in the following areas of concern:

1. Performance standards and practices for containers used for onsite movement of fissile and other radioactive materials.
2. Requirement of a quality assurance program applicable to the procurement of offsite shipping containers.
3. Documentation of technical backup support for specification and special permit containers developed for use to ship fissile and other radioactive materials.

Containers for Onsite Movement of Fissile and Other Radioactive Materials

Container design criteria for onsite movement are based primarily upon the contractor's judgment of good safety practices for credible conditions expected at the site or facility within his jurisdiction. These criteria are not in all respects the same as those applicable to packages that are designed for offiste shipments. However, the containers used for onsite movement of radioactive material must meet AECM 0530, "Nuclear Criticality Safety," and AECM 0524, "Standards for Radiation Protection." Also, for those cases wherein protection by design is not practicable, close control of transport conditions is required in lieu thereof to protect against the accident environment. While it is recognized that close controls coupled with safety requirements set forth in AECM 0530 and AECM 0524 are applicable to onsite movement of radioactive materials, broad standard performance criteria are necessary. Accordingly, the following requirements shall be implemented:

1. For the onsite movement of fissile materials that do not present a radiation hazard, the pertinent requirements set forth in AECM 0530 shall be met.
2. For onsite movement of fissile materials that present a radiation hazard as well as the possibility of an accidental chain reaction, the pertinent requiremetns of AECM 0530 and AECM 0524 shall be met.
3. For onsite movement of nonfissile radioactive materials, the pertinent requirements of AECM 0524 shall be met.
4. Administrative control, including traffic control, shall be exercised as deemed necessary by Field Office managers to minimize accident probability and the consequence of accidents if any should occur. Such administrative controls must, as a substitute for container design features, provide an equivalent degree of protection to personnel.
5. Fire protection, security, health physics, and any other emergency personnel when deemed appropriate by the Field Office manager shall be alerted and advised of movements and routings if such movements are over onsite roads.

A Quality Assurance Program for the Fabrication, Assembly, and Testing of Offsite Shipping Containers

Safety standards for the packaging of radioactive and fissile materials are set forth in AECM 0529. This chapter includes the design criteria to be met and testing procedures to be followed in the construction, procurement, and use of shipping containers and packaging for radioactive and fissile materials. It does not, however, include requirements for a quality assurance program. Hence, steps shall be taken to establish a quality assurance program to accomplish the following requirements:

1. Each Field Office shall require its contractors to establish and maintain a quality assurance program to assure that the requisite standards of quality are met in the fabrication, assembly, and testing of each package. The program shall consist of a formal system of procedural and organizational arrangements which:
    a. Require that specific responsibilities be assigned to designated units (including those of the vendor, the fabricator, and the contractor) for assuring specified quality at all stages of construction.
    b. Designates codes, standards, and specifications for materials, equipment, methods of fabrication, testing, and performance.
    c. Provides for quality control of materials, equipment, and services in instances where these have not already been established by existing standards and specifications.

d. Provides, as required by AECM 0504, for at least an annual audit of the AEC contractors' programs to assess their effectiveness.

e. Provides that quality assurance records are maintained in an auditable file during the service life of the container.

f. Provides for a method of determining that packagings procured for use from other sources including AEC contractors and subcontractors, or from licensees, meet the requirements of AECM 0529 and this IAD.

g. Establishes acceptance criteria in terms of measurable characteristics and the effects of appropriate tests prescribed in Annexes 1, 2, and 4 and as required in Part III.C. of AEC Appendix 0529.

h. Provides for a program of routine maintenance inspection and, where necessary, retesting to ensure that reusable containers continue to meet the applicable design standards.

i. Provides for required training, testing, and certification of manufacturing and inspection personnel involved in special processes, such as welding and nondestructive examination, and for the required certification of equipment and procedures used in the performance of special processes.

For guidance in evaluating the adequacy of a quality assurance program, see 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants."

Documentation of Technical Backup Support for Specification and Special Permit Packaging

Packagings for which specifications have been published in the DOT regulations or a special permit issued by the DOT may be used by any shipper having authority to ship radioactive or fissile materials. Therefore, it is essential that technical information and limits pertinent to the construction and use of these packagings be available to all potential users. Accordingly, steps will be taken to implement the following requirements:

1. Field Office managers shall require contractors under their jurisdiction to prepare a bound distributable document for each new specification, or special permit, packaging designed, developed, and fabricated by him for offsite shipment of fissile and other radioactive materials. Such a document shall also be required for existing packagings for which the DOT has issued special permits except in those instances of packagings of a highly specialized design and used solely by the originator. Should these specialized packagings be adopted for more general utilization, an approprate technical document must then be prepared.

It shall be the responsibility of the originator or first user to prepare the document for an existing packaging if it is to be used by other AEC Field Offices and contractors. Obsolete packagings no longer in use and containers used for onsite movement of materials are not subject to this IAD unless they are reactivated, altered, or requested for use in offsite shipments. In such instances the party or parties requiring reactivation and/or alterations shall prepare or have prepared the appropriate document.

2. Each document shall provide, as a minimum, the following information:
   a. A complete physical and technical description of the package.
   b. A safety analysis report including considerations for meeting the requirements for packaging and transport safety, nuclear criticality safety, and radiological safety. Pertinent documents in existence as of the date of this IAD are acceptable.
   c. Design and development information including pertinent data, analytical methods, and the results of the prescribed tests.
   d. Tables, graphs, drawings, pictures, and technical references as required to give a clear treatment of the subject.

3. Each document shall be prepared and submitted to the Division of Technical Information Extension in accordance with AEC Appendix 3201, Part III.B.2. for reproduction and distribution based upon need.

REFERENCES

1. D. E. Patterson, The Accident Experience of the USAEC in the Shipment of Radioactive Material.

2. TID-16764; D. E. Patterson; V. P. DeFatta; A Summary of Incidents Involving USAEC Shipments of Radioactive Material, 1957-1961; dtd Nov. 1962.

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5. AECU-3613; Safety and Fire Protection Branch; A Summary of Transportation Incidents in Atomic Energy Activities, 1949-1956; dtd Dec. 1957.

6. J. M. Morgan, Jr.; J. W. Knapp; and J. T. Thompson, A Study of the Possible Consequences and Costs of Accidents in the Transportation of High Level Radioactive Materials.

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"CELOTEX" - INSULATED SHIPPING CONTAINERS

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ABSTRACT

Seven different kinds of packages for shipping radioactive materials were developed at Savannah River Plant using "Celotex"* for thermal and shock protection. Twenty packages were dropped 30 feet at least once and eight packages were furnace tested at 1475°F. Military Standard drums were specified for all packages because of stronger construction and closer tolerances. Clearances between the "Celotex", the drum, and the inner container were minimized. Criteria for locking-ring tightness were established. The maximum allowable weight of a package with a 16-gage, 55-gallon drum was estimated to be about 600 pounds. Since "Celotex" is combustible and evolves gases when heated, drums were vented to avoid rupture in the furnace test. To prevent smoldering of "Celotex" after removal from the fire, refractory insulation material was placed adjacent to the vent holes to retard air flow into the drum. Samples of "Celotex" were heated at 250°, 300° and 350°F for 14 days. Compressive stress tests of the samples showed minimal effect on those that had been heated at 250°F. Above 280° to 290°F significant mechanical degradation occurs. "Celotex" smolders at 400°F and burns rapidly at 425°F.

Results showed that "Celotex" may be used successfully as an insulation material to comply with regulations for Type B packages.

INTRODUCTION

Seven different shipping packages for radioactive and fissile materials were developed at Savannah River Plant using "Celotex". The development program involved twenty full-scale packages all of which were dropped 30 feet at least once. Eight packages were

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* Celotex Corporation's trademark for bonded sugar cane fiber used as structural insulation and shock absorbing packaging board. "Celotex" industrial grade, as specified by MIL-F-26862A, was used for this work.

furnace tested at 1475°F for 30 minutes. Many other less significant tests comprising the sequence specified by shipping regulations were performed [1,2,3].

The program was initiated to develop a series of Type B packages for material of low decay heat. Minimum time was available to comply with recently revised shipping regulations. Six types of containers which had been previously used were well constructed and were integral parts of the processes of various facilities. To avoid process modifications, the existing containers were adapted as primary and intermediate containers, and overpacks of "Celotex" insulation and steel drums were developed. A seventh package was developed in its entirety to ship recovered uranium oxide from Italy to Oak Ridge. Figures 1 and 2 summarize the characteristics of each package.

Weight and size were limited to allow personnel to handle the packages within confined buildings without large material handling equipment. Minimum material and transportation costs were a secondary objective after consideration of safety and compliance with shipping regulations. So far as possible it was desirable to use the same packaging principles as used with current standard packages.

Several insulation materials were considered. "Celotex" was chosen because of its shock absorbence, thermal insulation properties, and durability. This paper presents some of the characteristics of "Celotex" and solutions of problems with its use.

IMPACT PROPERTIES

"Celotex" possesses more resilience than any material tested. Development of the JP-100 package involved several tests which demonstrate the material's capability.

Three JP-100 inner containers 8-5/8 inches diameter and 63 pounds each were nested in a clover-leaf pattern within "Celotex". The outer container was an elongated 55-gallon DOT Specification 17C drum. At the side only 1-1/2 inches of "Celotex" separated each inner container from the drum. The diametral clearance between the "Celotex" discs and the drum was 5/16 inch. Each inner container had a 1/4 inch diametral clearance to the "Celotex". The package weighed 348 pounds.

Figure 3 shows the package after both a 30-foot drop and a 40-inch puncture test. The outer diameter was reduced 3/4 inch from the 30-foot drop. The "Celotex" failed in tension at three places as the inner containers in the clover-leaf arrangement wedged the insulation apart at impact. Figure 4 shows the jagged 1/4-inch cracks in the thinnest "Celotex" sections. Radiant heat through the cracks during the furnace test would probably be excessive. Along the line of impact from the 30-foot fall, the "Celotex" compressed approximately 17% to a 1-1/4-inch thickness. Indentation from the 40-inch puncture test superimposed upon damage from the 30-foot fall gave a 1-inch thickness. Subsequent thermal tests showed that greater insulation thickness is required.

Another package was assembled using an 18-gage, 24-inch diameter Military Standard drum. The greater diameter allowed an insulation thickness of 2-1/4 inches at the side. The weight increased to 377 pounds. The locking-ring bolt was torqued to 20 ft-lb as the ring was tapped with a soft hammer. Impact on the side resulted in no cracks in the "Celotex", but the locking ring came off the curl of the drum as shown in Figure 5. The drum momentarily flattened at impact allowing the locking ring to slip over the curl. Negligible deformation of the locking ring and curl occurred.

The locking ring was replaced and the package was dropped 30 feet on its upper corner. Again the locking ring jumped off the curl and the curl unrolled. This allowed the cover and "Celotex" to protrude approximately 4-1/2 inches above the drum body as shown in Figure 6. Rigidity of the "Celotex" discs tended to make the side opposite to impact spring up and force the locking ring off the curl.

A 16-gage Military Standard drum was used in another package. Diametral clearance between the "Celotex" and the drum was 1/4 inch. Three 30-foot drops in different orientations were passed in succession.

A package for shipping uranium oxide from Italy to Oak Ridge was developed. A small dummy cask weighing 671 pounds was positioned in "Celotex" insulation in a 16-gage DOT Specification 17C drum. The total package weight was 846 pounds. Diametral clearance between the drum and

"Celotex" was 5/16 inch. Clearance between the dummy cask and "Celotex" was 5/8 inch. Approximately 100 pounds compression of the cover was required before engagement of the locking ring could be established. The locking ring was evenly tightened to give no more than 1/16-inch radial clearance between the drum body and the edge of the locking ring.

The package was dropped 30 feet on its top corner. The cover and "Celotex" opposite the point of impact sprang open approximately 8 inches as shown by Figure 7.

Another package was assembled with a 4-inch high shock absorbing structure welded to the cover. A smaller gap occurred. The package shown in Figure 8 with bolted flange reinforcement and weighing 880 pounds successfully passed the drop test on top and bottom corners.

The following principles for improved impact capability were developed from impact tests of various packages:

- "Celotex" discs must be machined to fit tight within the drum to support the drum during side and corner impacts. Allow a maximum of 1/4-inch clearance.
- Clearance between the "Celotex" and the inner containers must be minimized to 1/4 inch. Permit no voids which might allow disarrangement of broken "Celotex" discs at impact.
- Military Standard drums are recommended for all packages. Quality is good, and drawings are readily available and familiar to the container industry. Diameters have a ±0.03-inch tolerance allowing tighter, more reproducible fits between the drum and "Celotex". The curl was the largest and strongest found. Only a small cost premium is required.
- All drums 24 inches and larger must be 16-gage material regardless of package weight.
- Drop forged locking lugs are required.
- Procedures for tightening locking bolts while tapping the ring with a soft hammer are required to assure proper closure. A 1/16-inch maximum radial clearance between the drum body and the lower edge of the locking ring is a good control for tightness.

- The maximum allowable weight of a package with a 55-gallon, 16-gage drum is estimated to be 600 pounds. Further tests are required to establish an exact limit.

THERMAL PROPERTIES

"Celotex" is primarily cellulose. Consequently, when the material is heated to high temperature, combustible gases evolve and the outer surface of the "Celotex" burns if oxygen is present. Abnormal bulging of an unvented drum, observed during a furnace test, warned of impending rupture. All drums thereafter were vented, and no gaskets were used. Figure 12 shows the violent evolution of burning gases during a furnace test. Figure 11 shows a JP-100 package with three 3/8-inch diameter vent holes aligned vertically on the side. After removal from the furnace, natural convection through the vent holes allowed smoldering of the "Celotex". To prevent convection, vent holes were placed immediately under the locking curl. A 2-inch-square ring of "Cera Form",* an alumina-silica refractory insulation material, was inserted in the "Celotex" adjacent to the vents. Four subsequent furnace tests were sucessful with various packages. Figure 12 shows the "Cera Form" ring in LP-12 package. Another improvement resulted when a 1/2-inch "Cerafelt" * blanket was placed under the cover of the drum on top of the "Celotex" as shown in Figure 13.

"Celotex" charred approximately 1-1/2 inches deep for each 1475°F, 30-minute test. Several 450°F temperature indicating pellets buried 1-1/2 inches in "Celotex" were found melted on the high temperature side only. As a consequence, a 2-inch minimum thickness of "Celotex" was established.

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* Trademark of Johns Manville Corporation for alumina-silica refractory insulation material.

The quantity of radioactive materials which generate significant decay heat must be limited with "Celotex". Elevated temperatures for prolonged periods of time degrade "Celotex" structurally. Consequently, effectiveness of the insulation during impact and fire conditions would be reduced.

Samples of "Celotex" were exposed to 250, 300, and 350°F for 14 days. Thermal shrinkage and deflection from compressive loads were determined for each sample. The compressive stress varied from 0 to almost 90 psi. The range of stress was chosen based upon 8 psi static stress supporting the heaviest package and an estimated factor of 10 for inertial forces. The results are shown in Figure 15. A threshold point exists at approximately 285°F above which significant breakdown of "Celotex" occurs. An analogous threshold effect exists for wood.[4] For a safety margin a maximum normal temperature limit of 250°F should be used with "Celotex".

Samples of "Celotex" exposed to 400°F began to smolder very slowly beginning at the rougher surfaces and corners. At 425°F, samples burst into flame and burned rapidly.

CONCLUSION

Tests show that "Celotex" may be used successfully as an insulation material to comply with regulations for Type B packages. Since "Celotex" is combustible, great care must be taken to ensure that the outer container is not breeched either from impact conditions or from overpressurization by gas evolved from the "Celotex". Venting is required, but some mechanism to prevent smoldering must be present when the fire is removed from the package.

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3. U. S. Atomic Energy Commission Manual Chapter 0529 and Appendix 0529.

4. Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, "Ignition and Charring Temperatures of Wood", Report No. 1464, January 1958.

Information in this article was developed during the course of work under Contract AT(07-2)-1 with the Atomic Energy Commission.

NOT AVAILABLE AT TIME OF PUBLICATON

FIGURE 1

NOT AVAILABLE AT TIME OF PUBLICATON

FIGURE 2

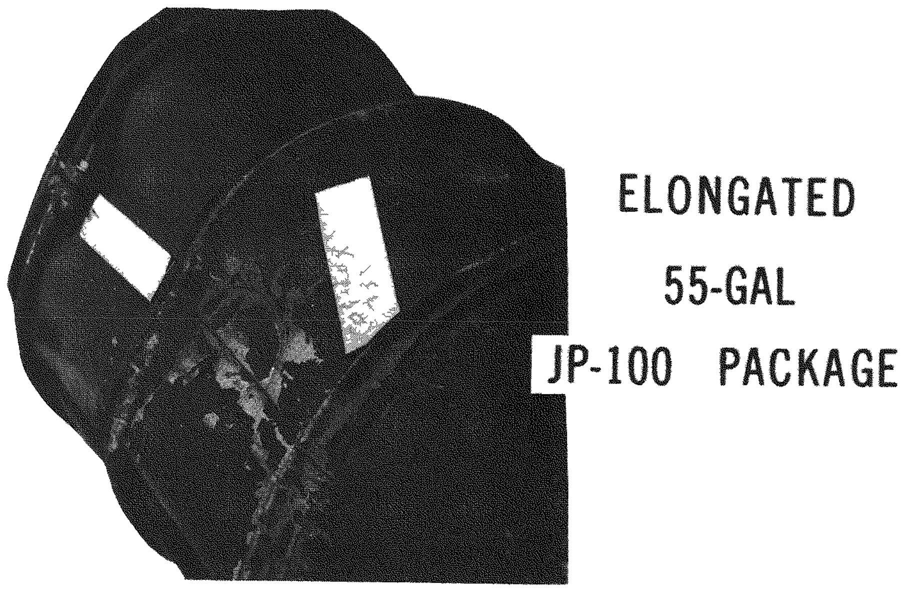


FIGURE 3

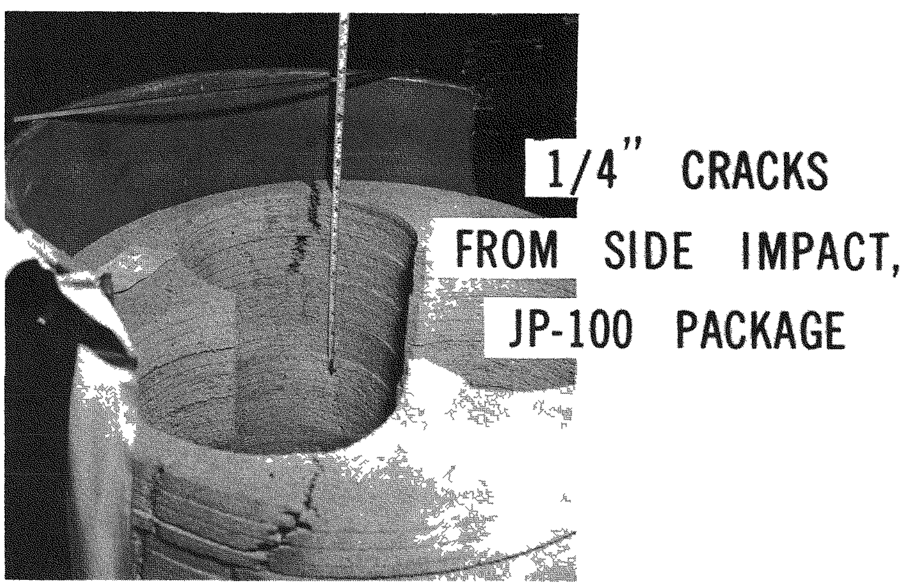


FIGURE 4

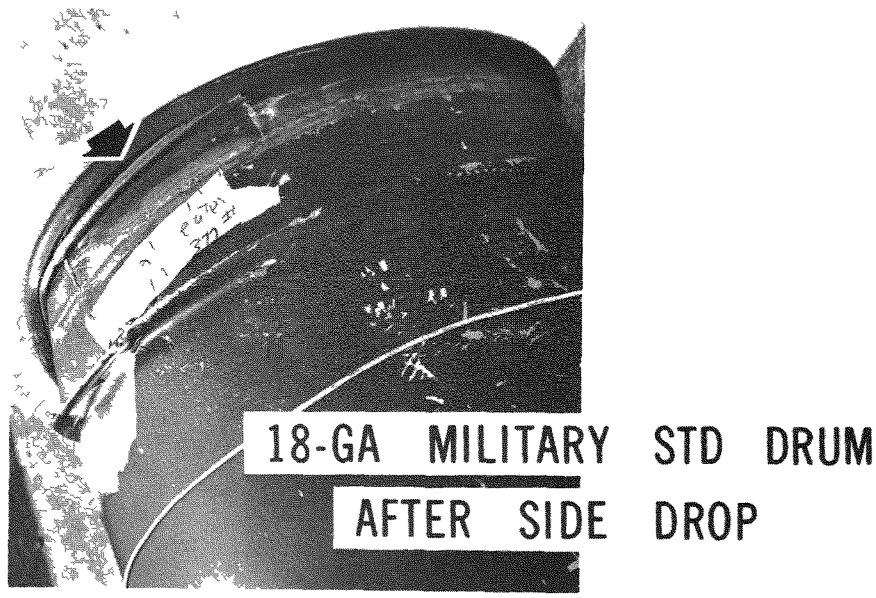


FIGURE 5

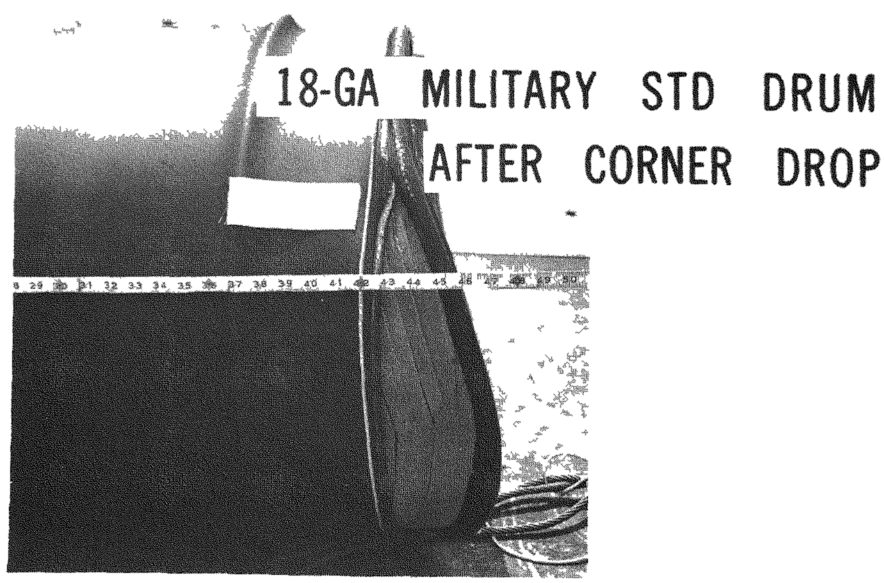
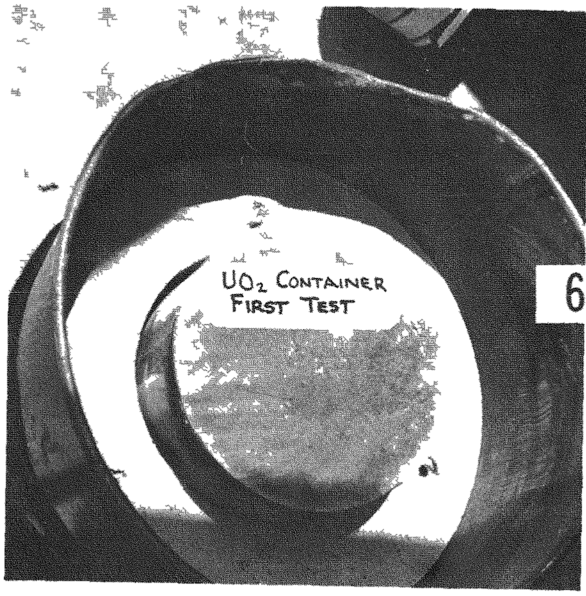


FIGURE 6

FIGURE 7

FIGURE 8



671-LB DUMMY
UO_2 CASK

FIGURE 9

FURNACE
TEST

FIGURE 10

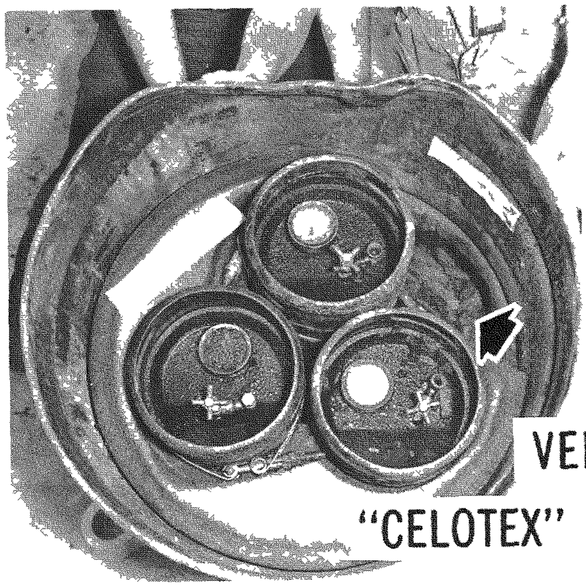


FIGURE 11

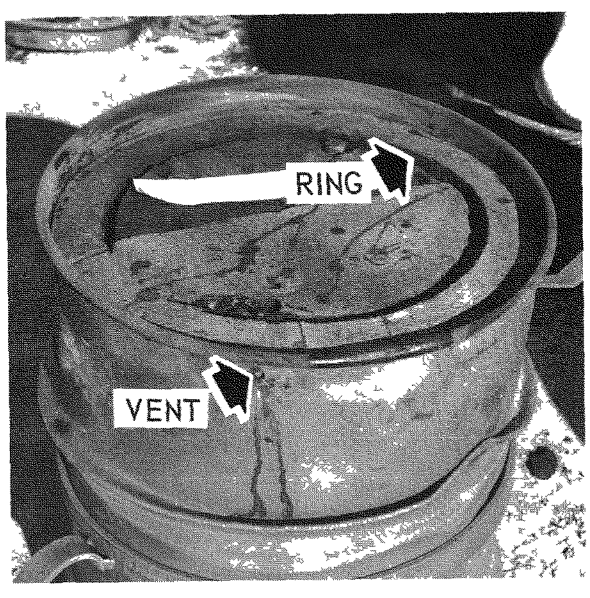


FIGURE 12

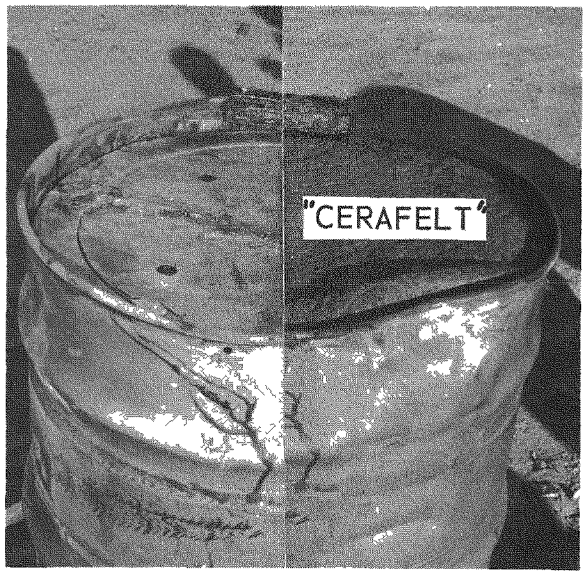


FIGURE 13

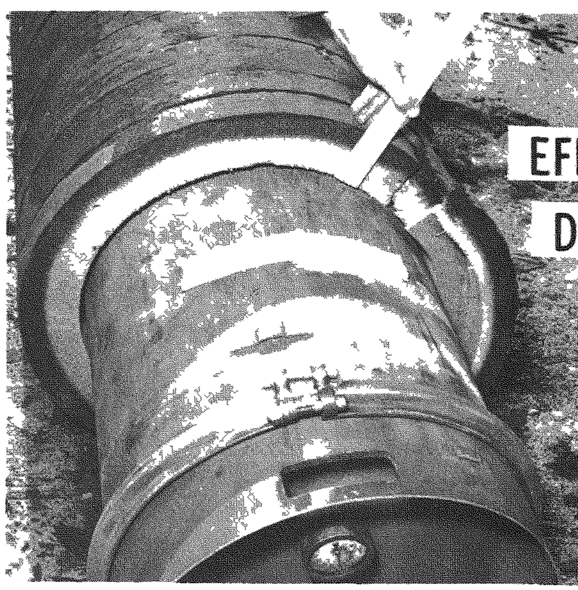


FIGURE 14

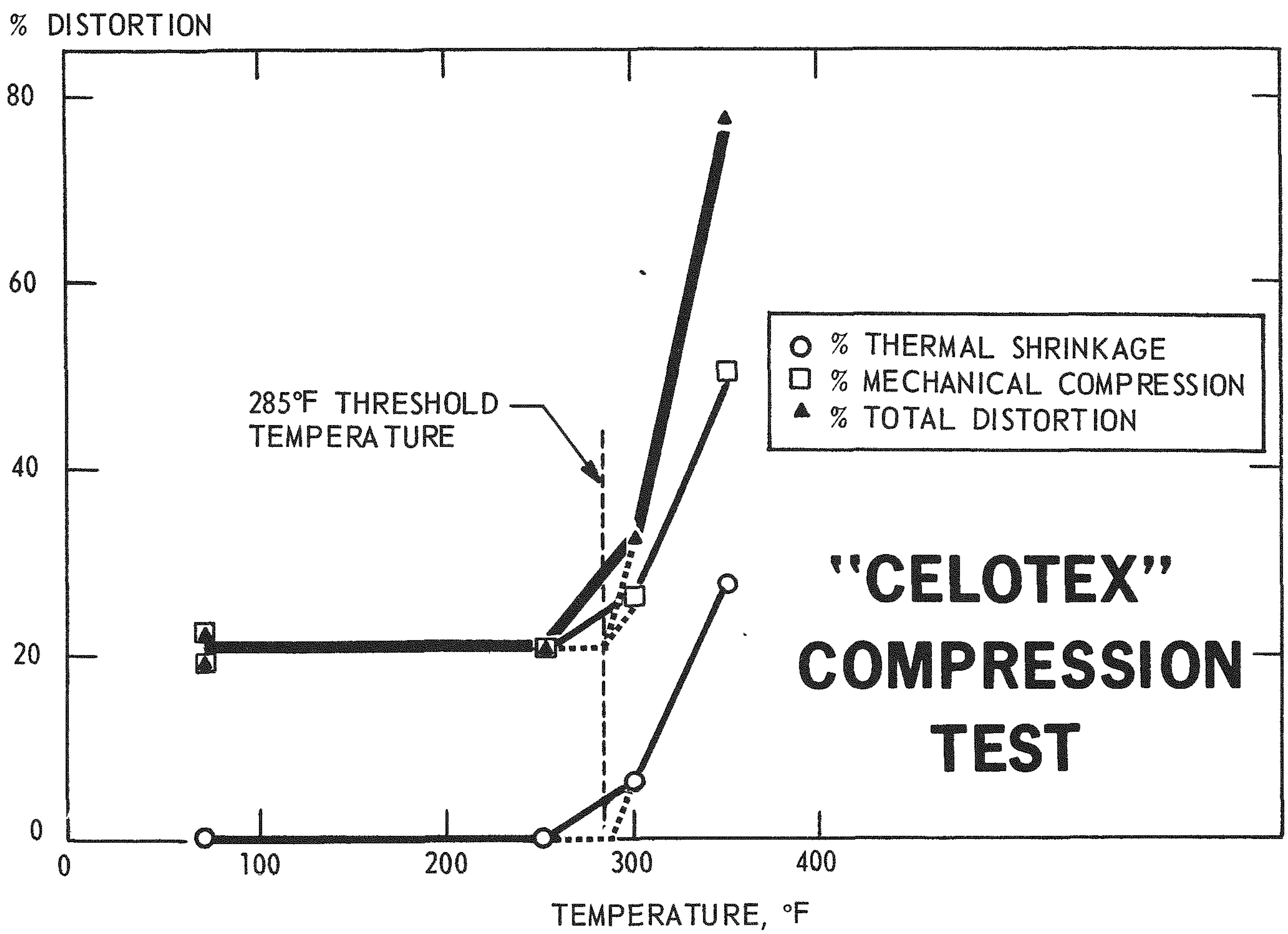

% DISTORTION
80
60
40
20
0
0
100
200
300
400
TEMPERATURE, °F
285°F THRESHOLD
TEMPERATURE
% THERMAL SHRINKAGE
% MECHANICAL COMPRESSION
% TOTAL DISTORTION
"CELOTEX"
COMPRESSION
TEST

FIGURE 15

PRACTICAL EXPERIENCE IN SPENT FUEL SHIPPING AND RELATION TO CASK CONCEPTS

Paul Blum   Henning Baatz

John Mangusi

ABSTRACT

A large number of shipments of spent fuel from 35 reactors to 9 reprocessing plants have given the Transnuclear group unprecedented experience in this field but not without encountering problems. This paper will describe some of these problems and indicate some safe and economical solutions with relation to cask concepts.

I. INTRODUCTION

The Transnuclear group has performed over 500 transports of spent nuclear fuel from many reactors* to nine reprocessing plants and has tried to utilize this experience in the design concepts for new casks.

This paper will concentrate on the contamination problems which we encountered moving light water reactor fuels and on the solutions we are adopting to minimize or eliminate these problems on our new casks under fabrication or design.

In the European context, where up to the present time the Transnuclear group has principally worked, if one points to a map of reprocessing plants and light water power reactors to be serviced, up to 1977, it is readily seen that:

*more than 35 reactors of all types: research, pilot, demonstration, power; and among the last: gas graphite, heavy water and light water.

- The tonnages to be transported are relatively modest (and subject to delay)
- Many of the reactors and some of the plants are not linked to rail transportation (or have no rail siding).
- Ocean transport will often be obligatory and often preceded by a somewhat long surface transport.
- For certain reactors the handling capacities are not very high and/or access to the storage pools is difficult.

Under these conditions, relatively light casks which can be transported easily by rail, road and ocean without necessitating heavy handling methods at the transfer points, seem to us to be the most appropriate always under the conditions that the payload is not too small and that the cost of manufacture remains low.

Our experience with our TN2 lead casks, which we have been using for many years across Europe for shipments of first generation light water reactor spent fuel (Trino, KRB, KOW, etc.) as well as for numerous shipments from other reactors and of fuel for post irradiation examination has shown us that their loaded weight of 32 tonnes lends itself very well to combined rail, road and ocean transportation using piggyback and roll-on roll-off systems without handling at transfer points.

Moreover, on many itineraries, which will become more numerous in the future, their GVW of 100,000 lbs. allows overweight permits to be obtained quite easily without severe restrictions.

Then, slightly extrapolating, improving the technology and performance, eliminating certain faults which our TN2 displayed during use, we have designed the TN8 and TN9 casks with the following characteristics:

- Loaded weight 33-34 tonnes (leading to a GVW of less than 105,000 lbs.)
- Capacity: 3 PWR assemblies (TN8) 7 BWR assemblies (TN9) of the new generation of power reactors (up to 1100 MWe)
- Heat Capacity: Up to 30 KW dissipated by natural convection.
- Solid Neutron Shielding outside the lead gamma shield.

Considering that the "useful load" of 1.2 to 1.4 tonnes of Uranium is sufficiently interesting, that the costs of manufacture remain relatively low (notably because of the use of lead as the main gamma shield) and that a high degree of safety is assured (as experienced in the use of TN2), we have chosen this design and we have ordered four of these casks which will be delivered in the first half of 1972.

If we now return to the map of Europe after the year 1977 and then consider the map of the United States followed by that of Japan we see:

- A prodigious increase in the tonnages to be transported
- Concentrations of several reactors at the same site (in general serviced by rail)
- Concentrations of sites in certain regions
- Establishment of reprocessing plants in the neighborhood or in the center of these zones.

It therefore becomes natural to envisage the transportation of these significant tonnages of spent fuel by rail utilizing the railroad capabilities to a maximum, that is to say, practically speaking, using 90-100 ton casks.

Even though economy, according to our current estimates, may not be a strong advantage of this solution, there are many evident reasons in its favor.

We, therefore, have a rail cask of this type under design and will be conducting preliminary tests in the beginning of 1972. As these casks represent large investments in studies and fabrication, one must make every effort to avoid any error in concept as well as avoiding premature obsolescence in foreseeing the possible evolution of regulations, technique and technology, etc.

We are also trying to introduce into our design a broader view than just that of the transport. In particular, we are trying to take into account problems of handling and storage from the shutdown of the reactor to the "dissolver" of the reprocessing plant.

The aim is to improve the economics of the whole process by eliminating or at least minimizing certain problems of the entire process currently encountered. For example, the problem of contamination of which we will now speak.

II. PERMISSIBLE LIMITS OF NON-FIXED RADIOACTIVE CONTAMINATION ON PACKAGE SURFACE AND CORRESPONDING MEASURING METHODS

II.1 As shown in table 1, the permissible limit of non-fixed contamination varies according to the regulation consulted and the IAEA limit is not generally the more restrictive. Incidentally, let us point out that decontamination is not to be likened to a usual household type cleaning operation and that an additional reduction by a factor of ten demanded by some regulations represents, in fact, the major portion of the job.

Table 1. Non-Fixed Contamination Limitations (microcuries/cm^2)

	IAEA 1967	DOT 1968	French Regulations
Alpha Activity	10^{-5}	10^{-6}	10^{-6}
Beta & Gamma Activity	10^{-4}	10^{-5}	10^{-4}
Reference Surface (cm^2)	300	100	300

Parenthetically, at this point, consider the difficulty one encounters when cleaning windows or eyeglasses. It is almost impossible to determine the cleanliness without taking advantage of the transparency of the material. Obviously, such a property is not available to assist the individual decontaminating a package surface.

Now what about the IAEA limit which corresponds to a single particle of Cobalt 60 having a radius of one micron collected from a 300 cm^2 surface of a package whose entire surface may be composed of several hundred square meters? Instead, if we assume that the contamination is evenly spread over the surface, we calculated that a monatomic layer of Cobalt 60 represents two million times this IAEA limit.

Actually the radioactive nuclides are generally diluted in a deposit comprising large amounts of non-radioactive dirt (dust, mud, grease, etc.) and the specific activity of the mixture may be considerably reduced. Nevertheless a difficult problem may still remain because of the low level of admissible contamination which is such that the contamination limit is exceeded although the specific activity of the mixture is low enough not to be considered "radioactive material" as defined by the IAEA regulations (minimum specific activity: 2×10^{-3} microcuries/gram).

This paradoxical situation may be encountered when a package is contaminated by a 25 micron thick layer of such a heterogeneous deposit of apparent density 2 gms/cm^3 over the swipe area of 300 cm^2 and which contains 2.6×10^{-12} gms of Cobalt 60.

In general, contamination is due to the simultaneous presence of several radioactive isotopes. Figure 1 is an example of a spectroscopic analysis performed on a smear test from the external surface of a cask carrying BWR spent fuel.

Since the measurements of contamination are normally made by scintillation counters or Geiger-Müeller tubes and not by spectroscopic analysis, it is difficult to interpret the counting when the spectrum is not known or the contamination varies during the decontamination.

Ignoring the spectrum and not using the appropriate equipment have caused cases to occur where the efficiency of the monitor has been overestimated and casks possessing contamination in excess of the limits have been permitted to be transported.

Another ambiguity, more commonly known, comes from the techniques used to acquire the smear; the pressure exerted on the surface by the operator and the actual area swiped.

II.2 Although the regulations take into account only two kinds of contamination:

- fixed contamination which interests mainly only packaging maintenance
- non-fixed contamination which determines practically the equipment and degree of the work needed for decontamination,

our experience leads us to consider a third type of contamination. We tend to call it "hidden" contamination since it cannot be detected even by very conscientious workmen. This last type of contamination can have several origins:

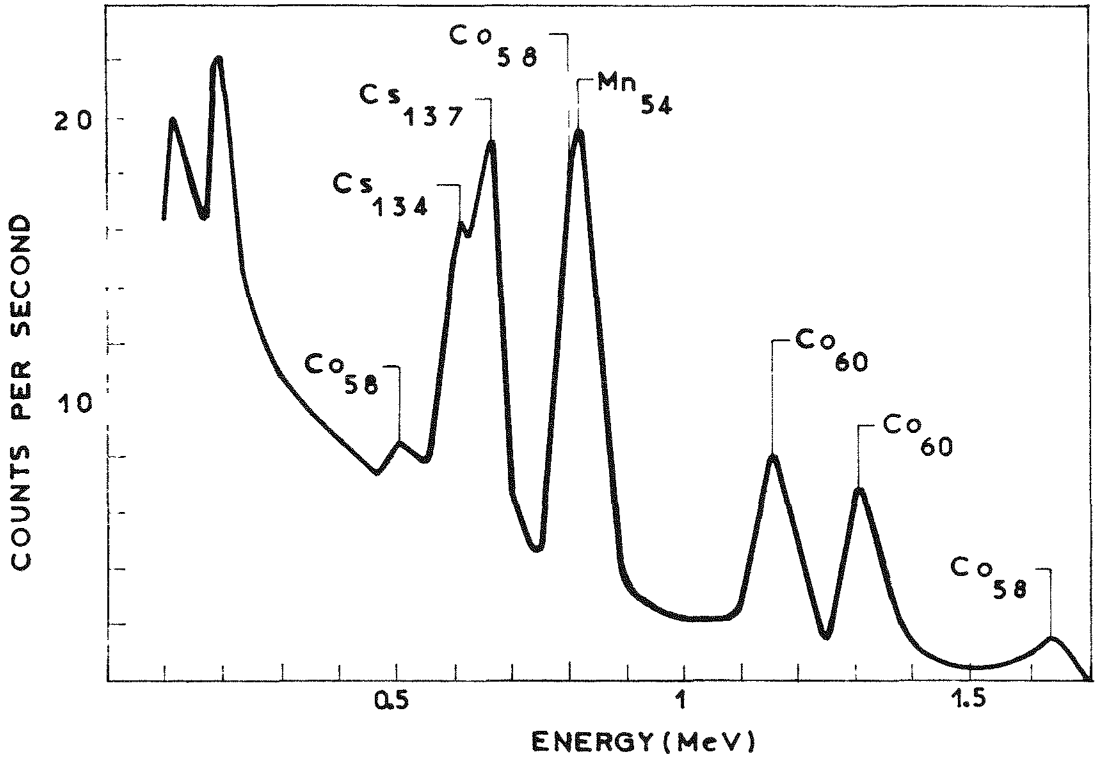


FIGURE 1. Spectroscopic Analysis of Smear Test

a. Release of radioactive deposits from certain parts of the casks not accessible to the operators making the smear tests:

- cracks and porosities of weld seams, mainly after several decontaminations by chemical pickling
- scratches on the external surface
- threaded holes for bolts and plugs
- spaces between flanges
- gasket housings

Grease, which is often used to facilitate remote operation of the bolts and to prevent seizing, increases the possibility of these accumulations.

Tilting of the cask and action of weather conditions can be sufficient to liberate these deposits and create very significant amounts of contamination which filters down onto the vehicle and the ground when the vehicle is stopped without taking special precautions.

b. Another frequently found form of this hidden contamination is due to sweating of decontaminated materials. Sweating, in this instance, is not to be confused with surface condensation, but is rather a migration of matter.

As this sweating is a reverse diffusion through the oxide or paint film covering the package surface, its rate increases with temperature increases. We have also observed that the more a cask is contaminated, the more we have a high sweating rate following initial decontamination. This phenomenon is more noticeable when a cask remains in a highly contaminated medium for a long time at rather high temperatures and mainly if the decontamination consists of spraying and brushing without pickling (in the case of stainless steel surfaces) or paint removal if the surface is painted.

We followed casks during their trip and performed periodic controls of contamination level. It was observed that the rate of increase was rather high and a factor of 30 was measured during a single transport. Sweating seems to be the only explanation for such an increase since the marked surface was protected during transport from any risk of contamination transfer.

These facts are the basis for the "way of life" which is often established between the reactor and reprocessing plant personnel in accepting, upon arrival at both sites, an average non-fixed contamination level which can reach several times the one which was within the regulatory limit as measured at the departure point.

III. POTENTIAL CONTAMINATION OF THE IRRADIATED FUEL ELEMENTS

III.1 The contamination that is measured on the packaging comes from the fuel elements transferring their own contamination, either directly during transport or through the water during loading or unloading operations in a storage pool.

Spent fuel, in fact, constitutes waste which the reactor personnel desire to get rid of at the best price but the characteristics of such waste are generally not very well known at the time of preparation for transportation.

More particularly, the defective assemblies, the proportion of which seems to be increasing, are not always well identified. In addition to the failures which have occurred during irradiation, one has to consider their possible extension as well as new defects which may appear during storage in the pool or during preparation for shipment.

Failure can also take place during cask loading or unloading as these wastes are not always handled with the same care as fresh assemblies. Since some rods are already defective at the time of loading, it is safe to assume that other rods are ready to fail caused by a small shock or temperature variation during transport. Our procedures for loading and unloading consider all these eventualities and have proven their efficiency for safe operation without prohibitive delay.

III.2 Most power stations, at the time of contract, asked us to provide capsules for eventual defective fuel. Sometimes the proportion of failed fuel encountered largely exceeded what was expected. We then analyzed the consequences of using no capsule at all.

Dry shipment combined with leaktightness of the cask even under accident conditions leads us to the conclusion that we could undertake the transport of defective elements without a capsule. Our experience in shipping defective elements in this manner has shown almost no buildup of contamination due to fission products and seems satisfactory for both the reactor and reprocessing plant.

Contrary to the above, we have experienced that there is an important risk of contamination due to crud deposited on the external surface of the fuel rods or foreign scrap trapped in the assemblies.

The amount of active crud is sometimes surprising and it is conceivable that the reactor operators are not willing to clean assemblies only for transport purposes. This crud deposited on the fuel rods consists mainly of very small particles originating from erosion and corrosion of the primary circuit of the reactor. One can also find in these deposits small pieces of grids, metallic wire, etc., the very high specific activity of which is caused by long irradiation times in the reactor core.

It can be seen that the activity of these deposits accumulated on the assemblies does not depend very much on the integrity of the assembly but rather on all the incidents which occurred in the core and primary circuit during irradiation.

Fission products originating from a defective assembly will contaminate the intact assemblies. One may fear that these deposits will become loose or disintegrate into small particles and settle in the packaging piping thus creating localized high radiation readings.

It seems that this risk is not to be felt with dry shipments but in either case at least a part of this fragmented crud goes into the rinsing water and into the unloading pool and the external surface of the cask can become highly contaminated. We have encountered this kind of contamination several times.

Although it is not our present intention to survey in such a short paper the respective advantages and disadvantages of dry and wet shipping methods, we wish to point out that the dry shipment seems to avoid the risk of stripping the crud deposits from the assemblies during shipment. It also does not cause the crud to be washed down nor the defective fuel element to be leached during transport as frequently occurs in wet shipping.

We agree that the temperature increase which is the consequence of dry shipments does not exclude all risks of rod failure. Nevertheless, we are not convinced that when the fuel assemblies are surrounded by water, the repeated flexures and corresponding fatigue associated with oscillations of the liquid mass during transport do not increase the risks of contingencies and failure.

IV. CASK IMPROVEMENTS RELATED TO THE RISK OF CONTAMINATION

IV.1 As already stated in the introduction, for the coming years our group intends to use 32-34 tonne casks having a capacity of either 3 PWR or 7 BWR assemblies but derived from the same basic design.

These casks have a barbell shape with a cylindrical mid-section and disc-shaped enlargements at the extremities in order to:

- increase the footing surface in the vertical position
- coordinate with the shock-absorbing covers which protect both extremities by absorbing any shock.
- protect the cooling fins, which are located between the enlargements, against risks of minor accidents during operation
- mainly permit adopting a removable skirt to prevent contaminating the fins while in a pool.

This skirt may be metallic or plastic. We have already developed one which is constructed of a rectangular plastic sheet, two sides of which can be joined by a zipper. The attachment of the skirt to the two cask enlargements is facilitated by a collar tightened by a quick operation connection.

In order to avoid the risk of contaminated water coming inside the skirt, we have provided connections to introduce clean water with a slight overpressure (see Figure 2).

Such a device which minimizes the risks of contamination has permitted us to use copper fins and an external solid neutron shield. Thus we are able to dissipate larger amounts of heat by natural convection together with a good neutron attenuation and minimum dead weight. (See Figure 3 which represents a

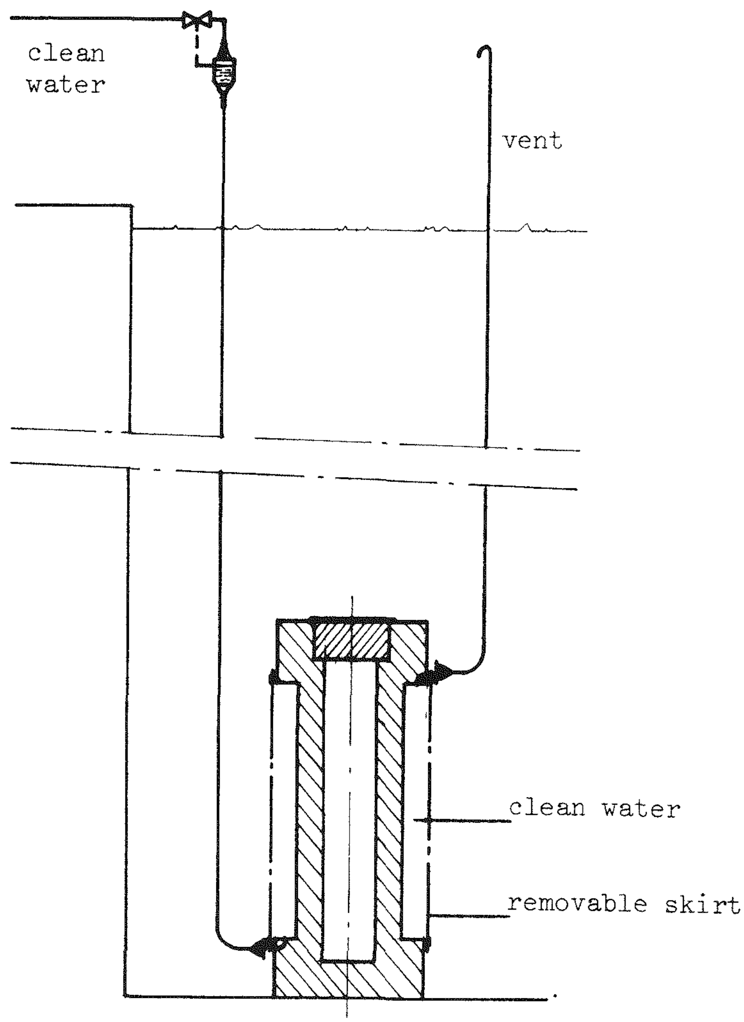


FIGURE 2. Removable Plastic Skirt and Associated Apparatus

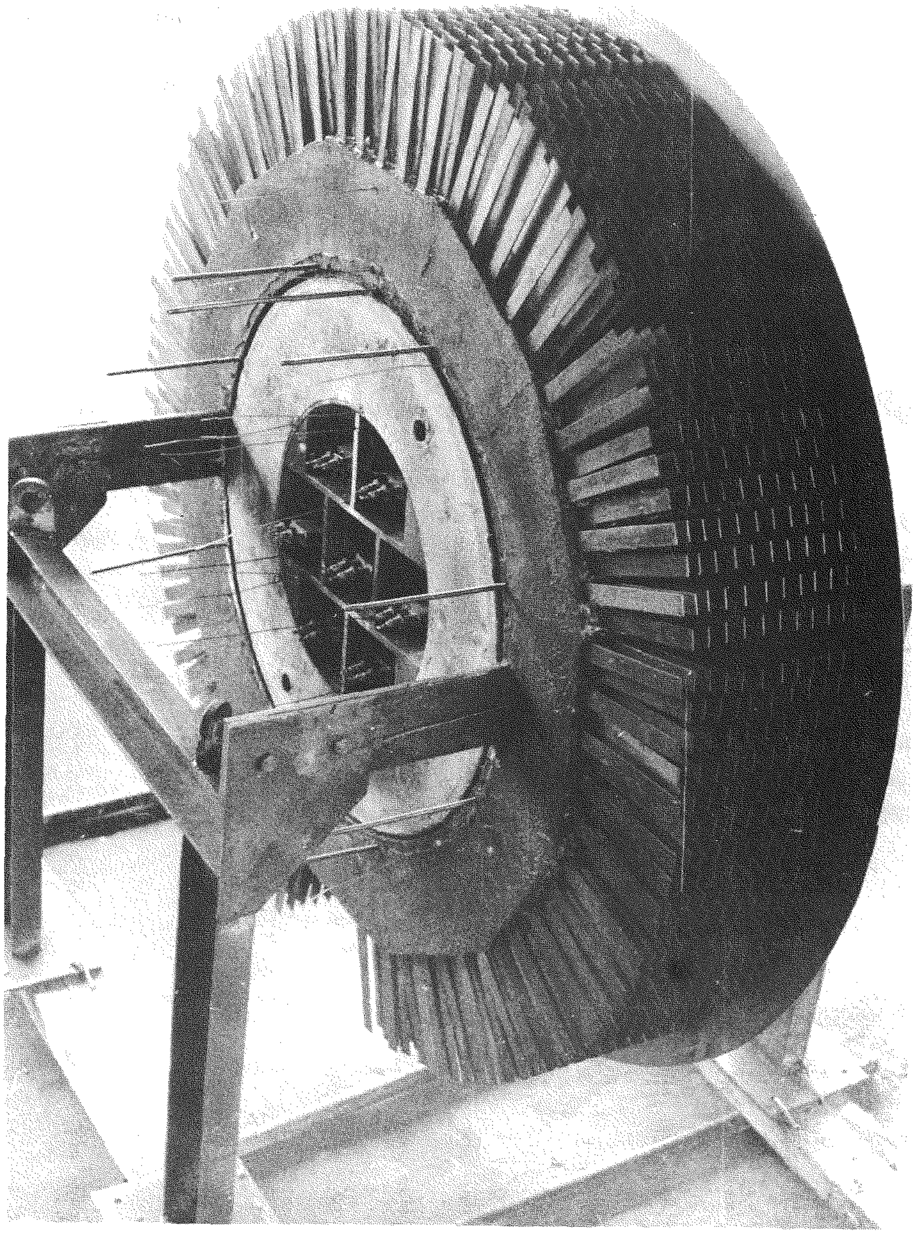


FIGURE 3. Full Size Center Section Slice of TN9

slice of the TN9 center section).

It should be noted that although we are using copper and a favorable fin orientation, the cooling surface is still quite substantial ($27 m^2$ for BWR assembly cask). With the exception of this finned area, these new casks are fabricated entirely of stainless steel. Even the removable shock absorbing covers are clad with stainless steel, as experience has shown us that they were not free from contamination risk.

Among other features which have been selected for our truck cask design to fight against contamination, let us indicate:

- straight drain pipe with a large diameter (50 mm) situated in the middle of the cavity bottom in order to facilitate rinsing operations and evacuating all the internal deposits.
- syphon drain which creates a stream of water which will reduce the pool contamination while taking off the lid and while unloading the fuel assemblies.
- possibility to use capsule if the condition of the assemblies is estimated to be too damaged to allow normal transport
- the fact that our casks are specialized which eliminates the need of basket changes with associated problems of internal contamination

IV.2 The rail cask which we have under design is characterized by the fact that it is composed of three independent, removable and interchangeable components (See Figure 4 representing a sketch of this cask):

a. Capsule -- The fuel assemblies are transported in a capsule which is constituted by an array of square steel tubes closed at one end and welded to a flange at the open end and covered by a leaktight lid.

b. Gamma Shielding -- The capsule is inserted in a gamma shielding which can be made of lead or uranium. This shield is fitted with handling trunnions and centering fins for positioning inside the pressure vessel.

c. Pressure Vessel -- This pressure vessel and flanged lid are made of stainless steel.

To dissipate the heat by natural convection, the central section of the pressure vessel is fitted with copper cooling fins. The heat transfer between

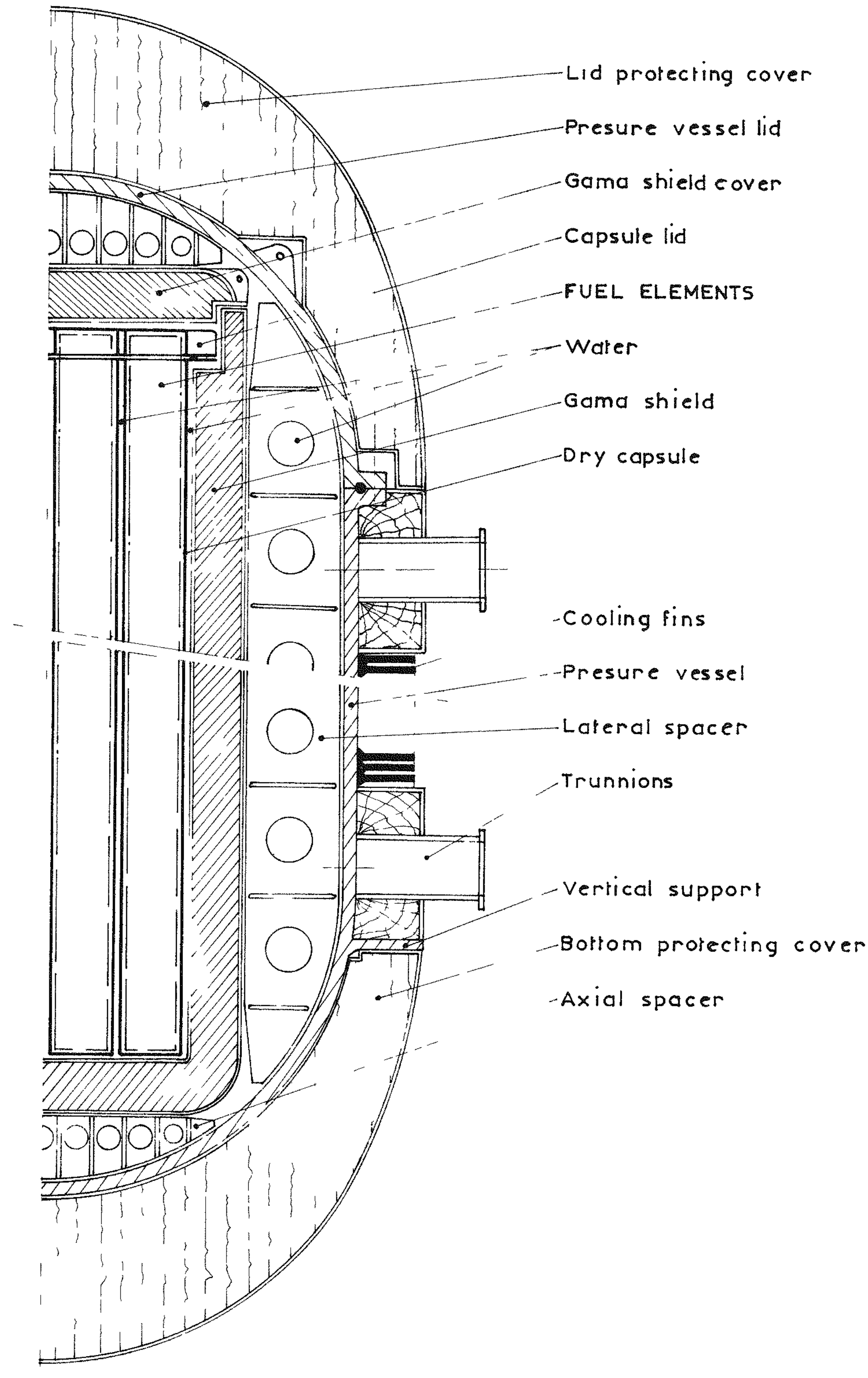


FIGURE 4. Rail Cask

the capsule and the pressure vessel takes place by convection of water circulating between the square tubes of the capsule, and through the gamma shield. The thickness of water between the gamma shield and the pressure vessel assures the neutron shielding.

One of the advantages of this concept is that the loading of the fuel assemblies in the capsule is independent of the loading of the capsule in the cask. It can be done in advance in a pool or a cell apart from the main loading pool or in a special area of this pool.

The reactor operator may even envisage storing the fuel assemblies in this capsule just after shutdown. Similar advantages apply to the reprocessing plant.

In any case, assuming that the capsules are externally decontaminated before their transfer into the cask, it can be seen that the contamination risk is greatly minimized.

In the case where the pool would, however, be contaminated, the external surface of the pressure vessel could be protected by the skirt system described above. There is also the possibility of not lowering the pressure vessel in the pool and handling only the assembly comprised of the capsule and its gamma shield, using a transfer sleeve.

V. CONCLUSION

Our experience shows us that we are going to be faced with contamination problems more and more often. In order to respect the regulations and maintain the greatest economy, we think a good solution is to design our casks and all procedures for maximum avoidance of contamination. This solution has the equal advantage of sharing the responsibility more evenly among the reactor, transporter and reprocessing plant.

THE EFFECT OF HIGHWAY WEIGHT RESTRICTIONS ON THE COST OF SPENT FUEL SHIPMENTS

K. H. Dufrane
E. D. North

ABSTRACT

The uneconomical aspects of rail transportation to many reactor sites combined with the large fraction of sites without direct rail access necessitates the development of an economic highway transportation system for handling spent reactor fuels. State Highway limitations on both weight and operating times provide economic restrictions which are critically amplified because of the low fuel payload carried relative to the shielded cask weight. For a selected typical case of an overweight cask carrying 3 PWR fuel assemblies in a 500 mile transport, the use charge for the cask alone almost doubles due to driving restrictions. If weight restrictions reduce the cask carrying capacity from 3 to 2 PWR assemblies per trip, an additional cost penalty of over 30% is found. This latter increase is further enhanced if the economics of site associated activities such as load-unload (turnaround) costs are also included.

INTRODUCTION

The cost of shipping spent fuel elements from the reactor to the reprocessing plant for the recovery of valuable uranium and plutonium fuels is significantly affected by restrictions placed upon special highway shipments. These restrictions are for overweight shipments and include limitations upon both gross vehicle weights and driving times (i.e., night, weekends, holidays). Rail transportation is generally not economically attractive compared to overweight truck shipments except for relatively long transport distances. This factor, combined with the reality that about 40% of presently planned reactor sites do not have direct rail access, requires that a viable highway transportation service be developed.

Highway weight and operating restrictions have not presented a significant problem to date for two reasons. First, only a relatively small amount of fuel has been shipped and second, cask utilization has been so low that frequently the time spent in transport was not critical. However, in the future, both these factors are reversed and the imposed restrictions will be felt quite heavily. In addition, as the second generation of spent fuel assemblies become available for transport, the cask weight required to carry the same number of fuel elements increases quite significantly. This is caused by a combination of both the increased physical size of the fuel assemblies and their characteristically higher irradiation power density and exposure (burnup) in the reactors.

DISCUSSION

The basic need for transportation starts with the nuclear power industry and follows its growth in a proportional manner. Figure 1 is a familiar curve which depicts the growth of nuclear power in terms of both installed electrical generating capacities and annual spent fuel discharged. In examining the annual discharge schedule, which is essentially a spent fuel transportation schedule moved forward by about 3 to 4 months, it is apparent that a significant increase is forecast over the next decade. In terms of actual numbers taken from this curve, a multiplication factor of about 30 (3000/100) would be applied to arrive

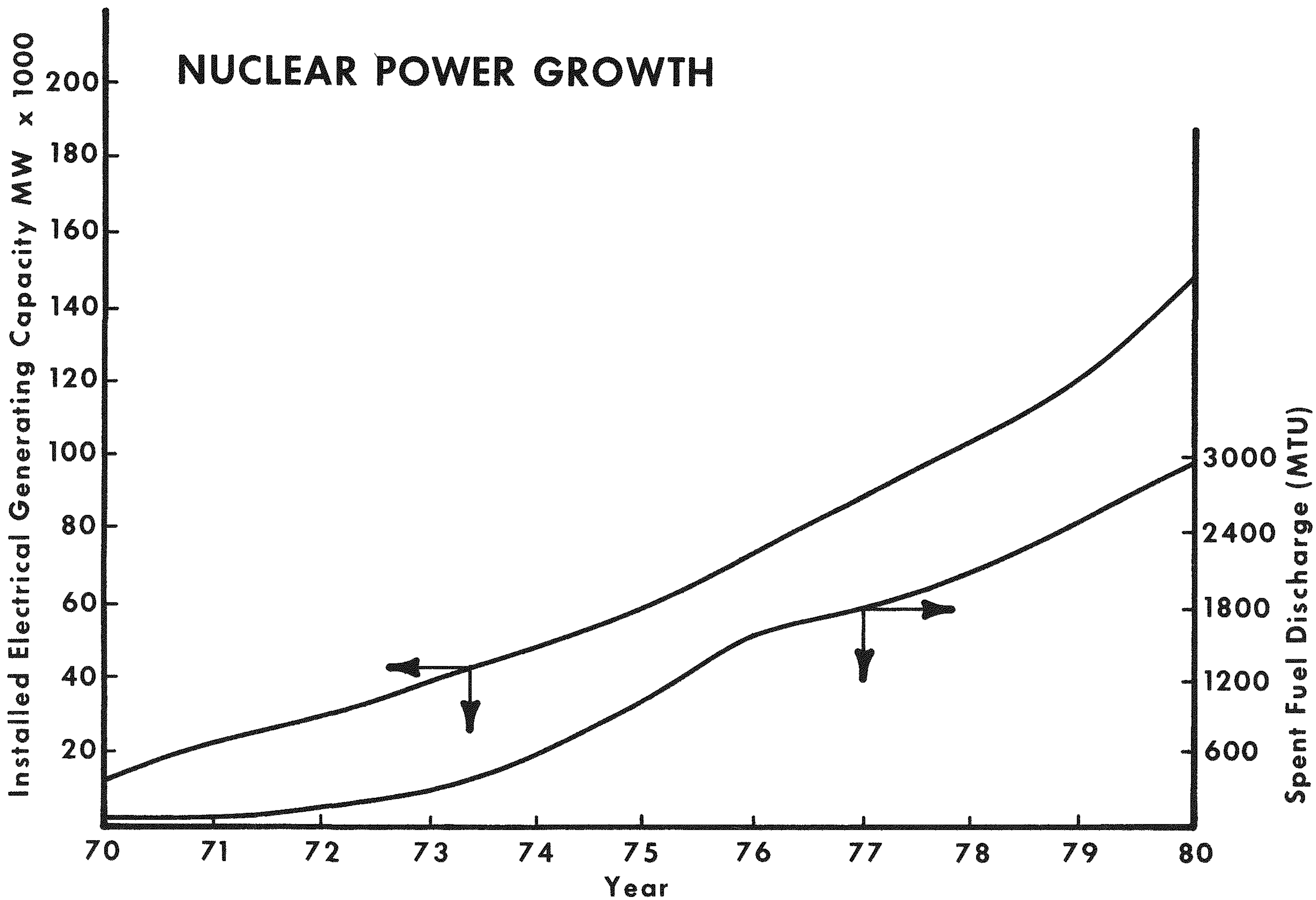

NUCLEAR POWER GROWTH
Installed Electrical Generating Capacity MW x 1000
200
180
160
140
120
100
80
60
40
20
Spent Fuel Discharge (MTU)
3000
2400
1800
1200
600
70
71
72
73
74
75
76
77
78
79
80
Year

FIGURE 1

at the projected 1980 transportation business. In terms of existing capability to perform this transport, the multiplication factor approaches infinity (3000/0) since no casks currently exist which are capable of handling the second generation fuel assemblies, which make up a vast majority of the fuel now being irradiated. However, casks with the necessary capability are currently being licensed and are scheduled to be available before the fuel under question is discharged from the various reactor plants.

Many different size shipping casks may be considered for each transport mode (truck, rail, barge, air) to handle this projected load. However, evaluations of various cask-transportation mode configurations generally narrows the selection to the five combinations discussed in the following paragraphs.

Legal weight truck shipments of about 73,000 lbs. gross vehicle weight (GVW) are readily acceptable in all states. They can operate around the clock, 7 days a week, with a carrying capacity of 1 PWR fuel assembly or 3 BWR fuel assemblies (approximately 0.4-0.6 MTU). Overweight trucks of about 90,000 lbs. GVW can operate in almost all states on a special permit basis, however restrictions on night and weekend operation are frequently applied. Carrying capacity is increased to 2 PWR or 4 BWR fuel assemblies (0.8-0.9 MTU). A further increase in transport weight to about 105,000 lbs. GVW is still widely accepted on a permit basis and provides a capacity of 3 PWR or 6 BWR assemblies (1.2-1.4 MTU). Weight advances beyond this are possible; however, state operational restrictions combined with technical complexities (i.e., criticality and additional heat rejection requirements) make a further stretch in this direction appear both technically and economically unattractive at present.

Rail casks are generally only attractive at their largest size. A 200,000 lb. cask (100 tons) is generally considered as an upper limit both from the standpoint of railcar carrying capacity and crane limitations at both reactor and reprocessing plant sites. These large casks will carry 10-12 PWR assemblies or 24-30 BWR assemblies (5-6 MTU). A combination known as a truck/rail intermodal configuration which uses a smaller cask, may be designed to service plants not directly on a rail spur. This approach would involve the extremely heavy truck haul of about 240,000 lbs. GVW to the closest rail spur, loading, and then subsequent standard rail shipment. Capacity would be about 7 PWR or 16 BWR assemblies (3.0 MTU).

One general area of interest noteworthy in the discussion of these various cask configurations, is the resulting size of the emerging spent fuel transportation industry. The projected annual discharges of Figure 1 may be combined with the carrying capacity of the various cask combinations discussed above to determine the required cask movements to service the nuclear industry. The results of this are presented on Figure 2 for a typical reactor-reprocessing plant distance under the assumption that all required transports were made by a single mode of transportation. As shown on this figure, an all-truck transportation system would require between 5,000 and 15,000 cask round trips per year in 1980 while an all rail system would require between 1200 and 1900. From a practical standpoint, considering both state and site restrictions, distances to be traveled, etc., it is anticipated that a combination of both rail and truck shipments would be used so that a reasonable total cask movement of 2-4000 trips/year would be anticipated. Other modes such as barge may be considered for isolated special cases, but normally would not be expected to play a significant role in the overall spent fuel transportation picture.

Now in limiting the discussion strictly to the highway transportation area for the purpose of this paper, it will become apparent that restrictive highway limits will have a substantial effect on overall transportation costs. Due primarily to the requirements for heavy shielding, the ratio of pay load to gross vehicle weight is extremely low -- at best 1 to 3%. When it is recognized that a single cask will cost from $150,000 to $500,000, depending upon size and material of construction, and that a single cask can transport only 50-100 tonnes of fuel per year, the large magnitude of the total investment required by the fuel transportation industry (and resulting costs) becomes readily apparent. This cost problem is further amplified by weight oriented freight costs which are based upon moving a large cask of some 50,000 to 80,000 lbs. containing at best a little over 2,000 lbs. of fuel.

The specific effect of various restrictions is perhaps best illustrated by examining selected cases. Figures 3 through 5 develop a relative cost comparison for two overweight cask configurations under various highway restrictions. Freight costs, which have been excluded for ease of understanding, would not change the relative results.

Figure 3 presents the number of trips per week that would be anticipated for a cask traveling 1,000 miles round trip between the power utility's reactor

REQUIRED SPENT FUEL CASK MOVEMENTS ASSUMING SINGLE MODE OF SHIPMENT

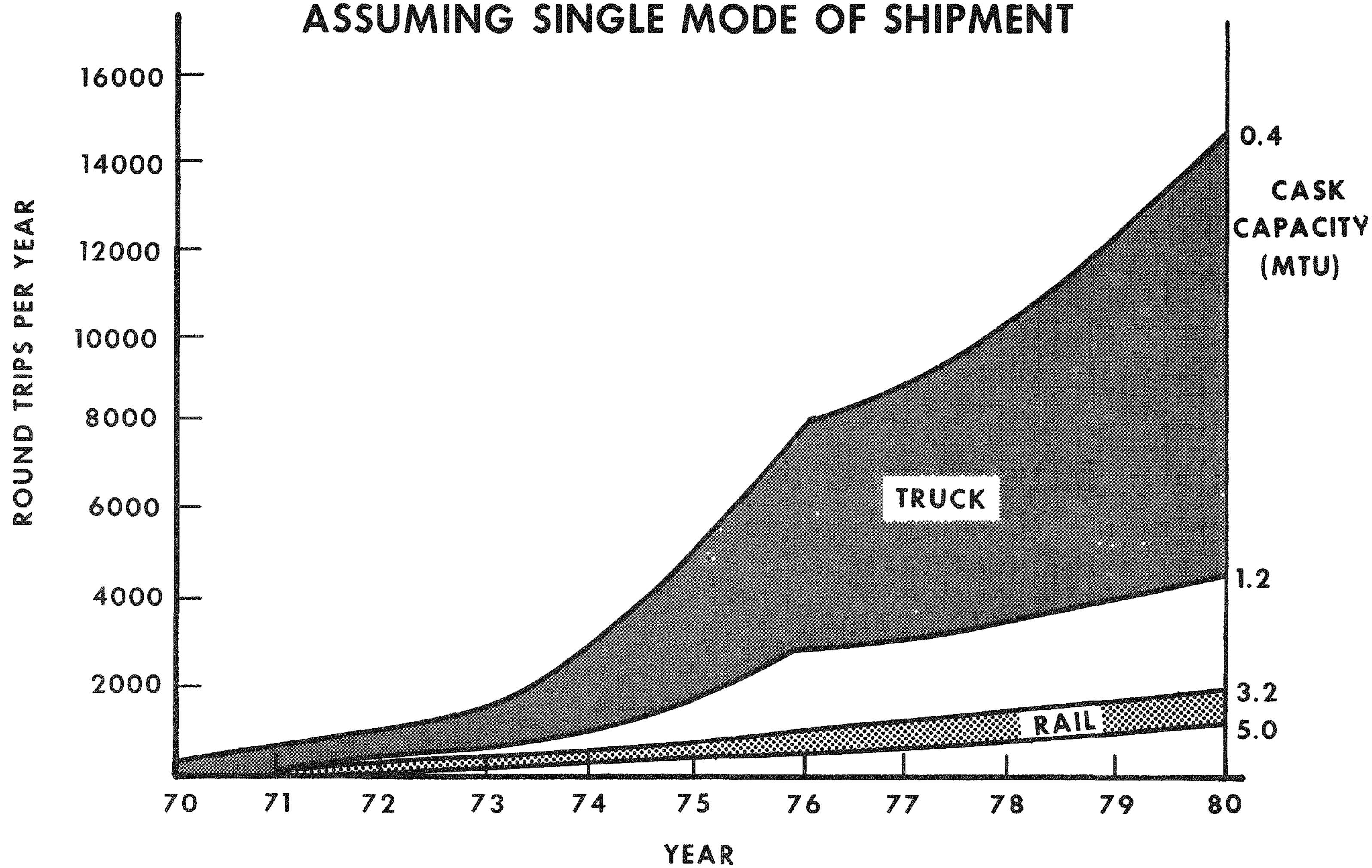


FIGURE 2

STANDARD TRIP

500 MILE ONEWAY DISTANCE
24 HR TURNAROUND AT UTILITY
24HR TURNAROUND AT REPROCESSOR
24 HR/DAY OPERATION AT UTILITY & REPROCESSOR

Average Travel Speed	Driving Restrictions	Trips/Week
	NONE	1.91
25 MPH	WEEKEND RESTRICTIONS	1.5
	NIGHT & WEEKEND RESTRICTIONS	1.0
	NONE	2.21
36MPH	WEEKEND RESTRICTIONS	1.66
	NIGHT & WEEKEND RESTRICTIONS	1.25

FIGURE 3

CASK USE CHARGE APPROXIMATION

Cask Capacity (tonnes)	Weight (lbs) Loaded Vehicle (GVW)	Weight (lbs) Cask	Cask Cost (dollars)	Cask Use Charge (dollars/week) Probable Range	Cask Use Charge (dollars/week) Selected for Study
1.35 (3 PWR)	105,000	75,000	500,000	3000 - 5000	4000
0.90 (2 PWR)	90,000	65,000	430,000	2500 -4500	3500

FIGURE 4

SPENT FUEL TRANSPORT COST

STANDARD TRIP OF 500 MILES
CASK COST APPROXIMATION
EXCLUDES FREIGHT COSTS

Average Transport Speed (MPH)	Cask Capacity (MTU)	Transportation Costs (dollars/MTU) Driving Restrictions: None	Weekends	Nights & Weekends
25	1.35	1550	1980	2960
	0.90	2040	2600	3900
36	1.35	1340	1780	2370
	0.90	1760	2340	3110

FIGURE 5

plant and the fuel reprocessor. A cask turnaround of 24 hours was assumed at both the reactor and reprocessor along with 24 hr/day, 7 day/week operation at each. These factors are quite obviously site, crew, and configuration dependent but the importance of these assumptions are minimal in the comparative analysis made since they tend to cancel out. Three sets of driving restrictions were considered: (1) none; (2) weekend restrictions -- i.e., no travel for 48 hours over weekends but with loading and unloading operations scheduled for any time; and (3) night and weekend restrictions -- i.e., travel only on 5 weekdays (no weekends) at an average of 12 hrs/day but with loading and unloading operations scheduled at any time. One can see from the results that at 25 MPH, the number of trips completed per week would vary between 1.0 and 1.9; at 36 MPH the number of trips would vary between 1.25 and 2.2. In both cases, the number of trips or what is really of interest, the amount of fuel transported would vary by almost a factor of two.

In order to evaluate this effect on transportation costs, one has to first determine the anticipated cask use charges. Figure 4 presents typical data on two casks of interest to this evaluation. A three PWR fuel assembly cask (which due to their smaller size would also hold 6 BWR assemblies) could carry about 1.35 tonnes of uranium in a 75,000 lb. cask at a gross vehicle weight (GVW) of 105,000 lbs. The cask, constructed with depleted uranium shielding in order to save weight, would cost approximately one-half million dollars. A smaller cask which would carry 2 PWR assemblies (4 BWR) would weigh about 65,000 lbs., provided a GVW of 90,000 lbs. and cost somewhat over $400,000.

The resulting charge for use of these casks would be based upon the following variables:

(1) Cask cost and desired return on investment

(2) Estimated Cask Life -- which may be either mechanically (age) limited or determined by changes in Federal Regulations

(3) Cask Utilization Factor -- the operational effectiveness or efficiency in approaching continuous cask operation

(4) Insurance Cost -- both on the cask and contained fuel

(5) Cask Maintenance Cost

(6) Fleet Management or Operations Cost

Items 2 and 3 are unfortunately both significant and difficult to predict. The mechanical life of the cask is quite long (at least 10-20 years) and generally not of concern compared to an effective life which may possibly be established by changes in Federal Regulations. To date, such changes have not tended to outmode a particular cask design as long as the contents to be transported had not changed appreciably. However, fuel assemblies do tend to change in both their detailed configuration and radiation characteristics and it is not possible to project what changes in Regulations might occur in 5 to 10 years. Cask utilization is a broad function of many time factors which must be evaluated by the cask owner or operator. These would include time related factors such as cask maintenance, scheduling, load availability, adverse weather conditions, truck breakdown, etc.

Since each independent operator will evaluate each of the six items listed (plus possibly many others) in a different manner and will consider the results highly proprietary, it is only possible to broadly estimate the resulting lease charges. A range of $3000 to $5000/week appears likely for the 3 PWR (6 BWR) cask and $2500 to $4500/week for the 2 PWR (4 BWR) cask. For the purpose of this paper, a specific value of $4000/week and $3500/week was selected (Figure 4) for the two cask designs.

By using these average cask use charges and the trips/week presented on Figure 3, the cask associated transportation cost per tonne of fuel shipped (excluding freight) may be readily calculated for the standard trip. As detailed on Figure 5, for an average transport speed of 25 MPH, driving restrictions placed upon the 3 or 2 PWR element cask would cause a variation on the cask transportation cost of $1410 and $1860/tonne, respectively. A combination of both weight and driving restrictions would provide a total differential cost of approximately $2,350/tonne. As the average transport speed increases (i.e., to the 36 MPH case studied) the incremental charges for the various restrictions decrease due to the fixed turnaround times but still remain quite appreciable.

As mentioned above, these increments only consider direct cask associated costs. Rather significant additional limitations and cost factors which would also tend to further magnify the differences include:

(1) Increased transportation (freight) cost and capital investment

(2) Increased number of cask turnarounds:
    Handling costs at utility reactor site
    Handling costs at reprocessor site

(3) Increased facility capital investment:
    Equipment at utility reactor site
    Equipment at reprocessor site

(4) Increased number of vehicles in transit

It is apparent that the inclusion of these factors in combination with the contributions of the basic cask cost would greatly enhance the dollar penalty presented by the potential highway restrictions. Such cost increments will not be borne by some company in a far off state, but will be borne directly by the customers of the power company operating the nuclear reactor. In effect, we will all pay for the increased cost of fuel shipments through increases in the cost of electricity.

This serious problem can only be resolved by action on the part of both the shippers and the various highway officials. The new interstate highway system will be nearly complete when significant quantities of fuels are scheduled to be shipped. This should ease many problems since these highways and bridges are built to higher load standards than were formally used. The shippers must work to reduce gross vehicle weights wherever possible and to develop new cask designs which will improve operating payloads. Highway officials should become more familiar with the overall problem and develop uniform requirements and procedures which are compatable with the overall needs of the power industry.

REQUIREMENTS FOR DEVELOPMENT OF SPENT FUEL SHIPPING CASKS

H. E. Walchli

ABSTRACT

The status of shipping cask design innovation has been retarded by the lack of common understanding and coordination between the utilities, the reprocessors and the cask designers. Current cask designs and shipping methods are not significantly different from the designs of 15 years ago. Experience in the shipping of spent fuel indicates that elimination of the need for decontamination would remove one of the largest labor and time consuming problems. To do this the entire system of fuel storage, cask handling, and transporting vehicle must be examined as a unified system. The large number of casks needed and the capital requirements indicate that action should be taken now to examine the feasibility of new concepts. Fuel and cask handling facilities should include adequate provisions in original plant construction to carry out necessary operations without need to backfit to each type cask. Increased attention should be given to personnel radiation exposure and safety in handling procedures.

INTRODUCTION

The first commercial power plants to require spent fuel shipments were the Yankee Atomic Electric and the Dresden nuclear reactors. This fuel was shipped, using truck and rail, to the only commercially operating reprocessing plant, the Nuclear Fuel Services plant at West Valley, New York. Since that time, fuel from several other nuclear energy plants has also been transported by commercial truck and rail. To our knowledge no incident has occurred that has created a public safety problem. In other words, even without extensive experience, shipping, in the hands of competent suppliers, can easily be carried out safely. Similar experience exists in England and Europe, where many spent fuel shipments have also been made.

In examining the progress in the changes in design of shipping casks we find that a cask of 1970 style varies only a little from that of 1960. Cask designers have progressed amazingly little in arriving at new concepts for shipping. A reason for this lack of progress is that (in most cases) cask designers are either fabricators with little knowledge of reactor plant layout and facilities, or are researchers with a similar lack of plant handling experience. In addition, cask designers have had to spend available time and funds on the reproofing of old designs with each new change in regulatory personnel. This continual re-analysis has caused designers to shy away from changes and the development of new concepts because of the added costs of licensing revisions. In addition, little or no assistance has been given in the way of research support by the user utilities and the reprocessors.

It is not my purpose here today to discuss the regulatory requirements or the solution to problems associated therewith. I am sure the ingenuity of modern technologists will continue to demonstrate to the world that transport of spent fuel can be made without hazard to the public.

It is my purpose here today to call upon the electric utility industry, their architects, and their engineers, and with those in the cask and transportation industry to actively join together to arrive at more economical and easier methods for fuel handling and shipping.

The task of shipment of spent fuel should not continue to be a series of individual ideas and methods requiring special equipment and different procedures at each reactor site. The movement of spent fuel from its storage rack at the utility to delivery to the storage position at the recovery site should be examined as a system; the equipment and designs should be compatible with the needs of that system and standardized to the greatest degrees practicable to permit utilization to the maximum at all plant sites.

Permit me to illustrate for you why I believe that now is the time to begin to solve the system problems. I shall do this in the following paragraphs by:

1. Forecasting the shipping requirements over the next 15 years to demonstrate the sudden growth of this industry.

2. Examining the costs associated with this shipping requirement to indicate the large amounts of capital that are required for casks and equipment that are not usually required in the transport industry.

3. Questioning the industry capability to produce the equipment on the needed schedule with present facilities.

4. And finally by suggesting some changes in concepts that bring into consideration experiences gained on early shipments.

SHIPPING REQUIREMENTS

The AEC in their 1970 issue of The Nuclear Industry published a graph of fuel reprocessing capability, and an AEC forecast of reprocessing load to 1980 has been converted to the number of shipments that might be required, based on the assumption that all current and projected future plants begin and continue to operate on schedule.

The number of fuel shipments will vary directly with the amount of fuel that can be carried in a single shipment. The analysis in this report is based on a shipping weight of 1 metric ton of fuel per shipment. Should you prefer to estimate a different value, it will therefore be easy for you to multiply the quantities given herein by your factor. I have selected metric ton for a number of reasons.

In examining the location of existing nuclear plant sites we find that 25 to 35% of these plants are at locations where access by rail is not readily possible. These sites certainly will require truck shipment. Another 10-20% of the plants, although having access by rail, are sufficiently close to a reprocessing plant that delivery by truck may be quicker and less costly than by rail if suitable methods are devised to reduce on-site handling time. For the remainder of the sites, shipment by rail or barge is feasible.

Existing highway weight limits are such that total gross weights in excess of 36 tons require special permits, and maximum overweight permit limits vary from 45 to 60 tons with different states. In many cases the bridges and culverts on older highways just cannot take continuous repetitive loading above these amounts and considerable reconstruction would be required for greater loads. Using existing concepts for casks, it appears that these weight restrictions will limit the cask volume to a size capable of holding about 2 of the largest PWR type fuel units and 4 or 5 BWR units.

In Figure 1 we have an outline of the growth in the general size of reactor fuels since 1957. Fuel about 2 feet longer than that shown here is now being projected for next generation reactors. For this longer fuel, casks for highway use would be limited to two PWR type units and the loading would be about 1 metric ton.

In Figure 2 we show the number of shipments that are forecast through the late 1980's for the U.S.A. In 1980 there will be somewhat more than

3000 shipments per year. However, the increase thereafter as more plants come on line, indicates about 11,000 shipments (about 32 per day) will occur in the late 1980's. Hopefully by that time, larger casks and rail shipments will be readily available.

Casks Required

If we estimate the time required for turn-around and transit we can predict the number of casks required to make 3000 shipments in a year. If we assume a cask can be loaded in 24 hours, transported from reactor to reprocessing plant in 24 hours, and unloading completed in 24 hours each cask can at the very most make 1-3/4 shipments in a seven-day workweek. If we assume 90% utilization with time out for maintenance, bad weather and the like we will have 45 weeks of operation per year and one cask can handle 78 shipments per year. To complete the 1980 requirements about 39 casks will be needed. In actuality, I do not believe it possible to maintain this short schedule with present cask designs and present handling and decontamination requirements. For example, to ship fuel by truck between Los Angeles and Chicago now requires a cycle time of about 10 days. If all shipments took 10 days, about 100 casks would be required to complete the work load of 1980.

By 1987, if we find the shipping requirement of 11,000 tons is valid, a minimum of 140 casks will be needed if all casks are for truck type shipments. If we assume 50 percent of the shipments can be made in larger casks handling five tonnes of fuel, and these larger casks can make a shipping cycle in two weeks, we still will require 48 of these new large units, plus 70 of the truck sized casks.

At the present time there are no casks in the U.S.A., or to my knowledge anywhere in the Free World, that can carry two of the current generation PWR fuel units. Several groups have designs under way, but (regrettably) they are not universally compatible with many of the current power reactor facilities.

Capital Costs

Let's examine the capital requirements. A cask capable of carrying one MTU will weigh 33 tons. If we assume a fabrication cost of two dollars per pound and assume all casks are of like design, the cost of each unit would be $132,000. Actual current prices for uranium shielded casks are at least double this price. To this figure must be added the costs of the transport vehicle and engineering and licensing costs.

Unlike most transport industries the vehicle is not available for other service and the cost should be included with the cask equipment. New transport freight rates must be established, since if vehicle capital is included in equipment costing rates the carrier does not have to bear this portion of the cost. At a minimum, we are talking five million dollars and perhaps as much as 35 million by 1980. By 1987 this industry represents an accumulated capital expenditure of between 30 and 60 million dollars and continues at a rate of 1.5 million annually thereafter.

Fabrication Capability

If we assume the need for these casks is a linear time function, the annual production rate will be four casks per year through 1980 and an average of 10 per year during the next 10 year period. The increase after 1980 is not linear and the production rate at 1980 would be less, and in 1990 much more than the average 10 units. The point here is that the existing fabrication facilities appear to be inadequate for the 1980 period when 5 of the 10 casks per year will be units weighing 100 tons or more, requiring heavy mills and special lead pouring facilities. Should uranium metal become the basic shielding material, the problem of adequate fabrication facilities will become even more acute. Without new fabricators and competitive industry the two dollars and four dollars per pound of my earlier estimates may be found to be much too low. I have not attempted to include material and wage escallation in these gross estimates, but this must not be overlooked in examining the future economics. The purpose of this discussion is not to present an exact economic analysis of feel shipping, but to show that unless efforts are made to improve and standardize designs, costs will become even higher than these projections.

Operating Experience

Based on the experience we have had to date, eliminating regulatory and highway weight difficulties, the single biggest problem has been associated with decontamination of equipment. The time required to scrub equipment, take contamination smears and reach acceptable results will, of course, vary with the degree of pool contamination and cask surface conditions. Cask surface contaminants almost always increase with time as the surface dries and contaminants oxidize. High levels of removable contamination almost always exist near the fill and drain valves and the closure flange. As spent fuel pools become more highly contaminated and the surface condition of casks through use becomes rough and scarred, this problem will increase unless systems can be devised to keep the casks from becoming contaminated in the first place. Many methods have been tried with varying degrees of success, including those where the cask has been wrapped in a nylon bag prior to insertion in the pool.

Another system that has been proposed, but to my knowledge has not yet been used, is to put the cask into a larger container which is filled with clean water. This container (with the cask inside) is then lowered into the pool. This system has the added advantage that the cask handling tools do not have to go into the water since the outer container can be handled with tools which remain on site. The cask and container could, in fact, be lowered into the pool by an elevator device rather than an overhead crane. This method would at the same time minimize the hypothetical "cask drop" accident. Keeping the cask loading pool area segregated from the main storage pool will also minimize the cask pool water contamination.

Another method proposed by one author is to load the fuel into a suitable partially shielded container. This smaller container is then placed into a structure which serves as the transport vehicle body, and at the same time supplies additional shielding required during transport. This method eliminates the decontamination step almost completely.

Personnel

To provide a 24 hour turn-around at the utility site it will be necessary to utilize a three or four man crew on a three shift per day basis. For a core having 30 tons of fuel to ship in a batch, this crew would be required to be available full time for a period of about three months each year only if truck casks are used. The gamma and neutron flux allowed at the surface of the cask can be anywhere between 10 and 200 mr. (depending on cask size). If quarterly radiation exposure limits are approached due to the decontamination operation, additional personnel might be required. Minimizing the decontamination time also minimizes the personnel exposure.

With existing cask designs, a limiting factor in cask handling is facility crane utilization. Casks handled entirely by overhead cranes require use of the crane hook 100% of the time during cask handling. If shipments are to extend, on the daily basis, over four or more months, it becomes obvious that the crane should not be depended upon for any other daily routine service.

Alternate methods of off-loading, moving and rotating of casks should be investigated, such as use of air pallets and power dollies. Facilities could be designed to up-end casks by special tilt tables if design of cask is made a part of the system design when plants are initially constructed.

A shipping cask in excess of 16 feet long is required to handle fuel having lengths in the order of 14 feet. When in a vertical position, facilities must be available to permit ready access to the top of the cask by health physics personnel for contamination and radiation surveys, as well as for the decontamination crew. Head bolts that must be torqued to several hundred foot pounds require using heavy impact wrenches. In many cases the weight of these wrenches may exceed the weight maximum that can be legally lifted manually under State Workmen's rules. Provisions should be made for getting the necessary tools and parts readily available to personnel involved in closing, venting and sampling casks at the required elevations. Use of special scaffolding or platforms designed for safety and economy of operation should be an integral part of the initial plant design. Rinse rings for spraying the cask and other tools as they are removed from the pool should be an installed plant item, as well as controlled air jets for rapidly drying the casks.

Plant facilities should have available close to the cask handling area adequate facilities for clothing change and personnel decontamination and monitoring. Use of oversize rubbers, and canvas foot covers intended for use on flat floors will certainly lead to extra personnel hazard on ladders amd impromptu scaffolding. As much care should be taken in assuring safety to the handling personnel as is taken to assure safety to the public.

SUMMARY

The present concept for cask design, which requires specialized handling tools and considerable decontamination, does not appear to be the best solution to spent fuel shipping.

The number of casks required during the next 15 years indicates this to be a substantial fabrication business which will require additional fabrication facilities and fabricators.

The numbers of shipments of fuel required will produce a need for good reliable carriers, and a trucking industry not only interested in cents/mile but also in the design and ownership of integrated casks and transport vehicles.

Every effort should be made to allow maximum possible highway weights without night and week-end travel restrictions, since these shipments are simply heavy and not oversized.

The trucking industry will be called upon to supply qualified and reliable drivers and well-serviced equipment to maintain the tight shipping schedules.

Since leaky fuel may require canning prior to shipment, the maximum canned fuel that can be put in a cask is even more limited than that assumed in this discussion. Eventually, all fuel might be shipped as canned fuel since it may be cheaper and easier to can fuel than to check for leakers or perform tests to assure that cask coolants meet all of the AEC requirements. Shipment of fuel in a dry state would minimize accidental loss of contaminated coolant, but would require development of an alternate method of "neutron shielding" required of high burn-up fuels. Shipping dry and in a sealed can might prove advantageous if this method is examined on a systems basis, including the system used to handle and store leaky fuel at the reactor site.

The utilities, their architects, and the cask designers must collaborate to arrive at a system that optimizes the shipping time and costs, with consideration for required plant personnel at both the utility and the reprocessor sites. Joint efforts should be undertaken to assure that maximum utilization of transport casks and equipment can be achieved and that the problems of storage, leak testing, and handling are considered in the fuel shipping cycle. More detailed analysis should be given by the utilities and the architect to the procedure and methods to be used in spent fuel and radioactive waste disposal to assure each operation can be done safely and with a minimum exposure of personnel to radiation and contamination.

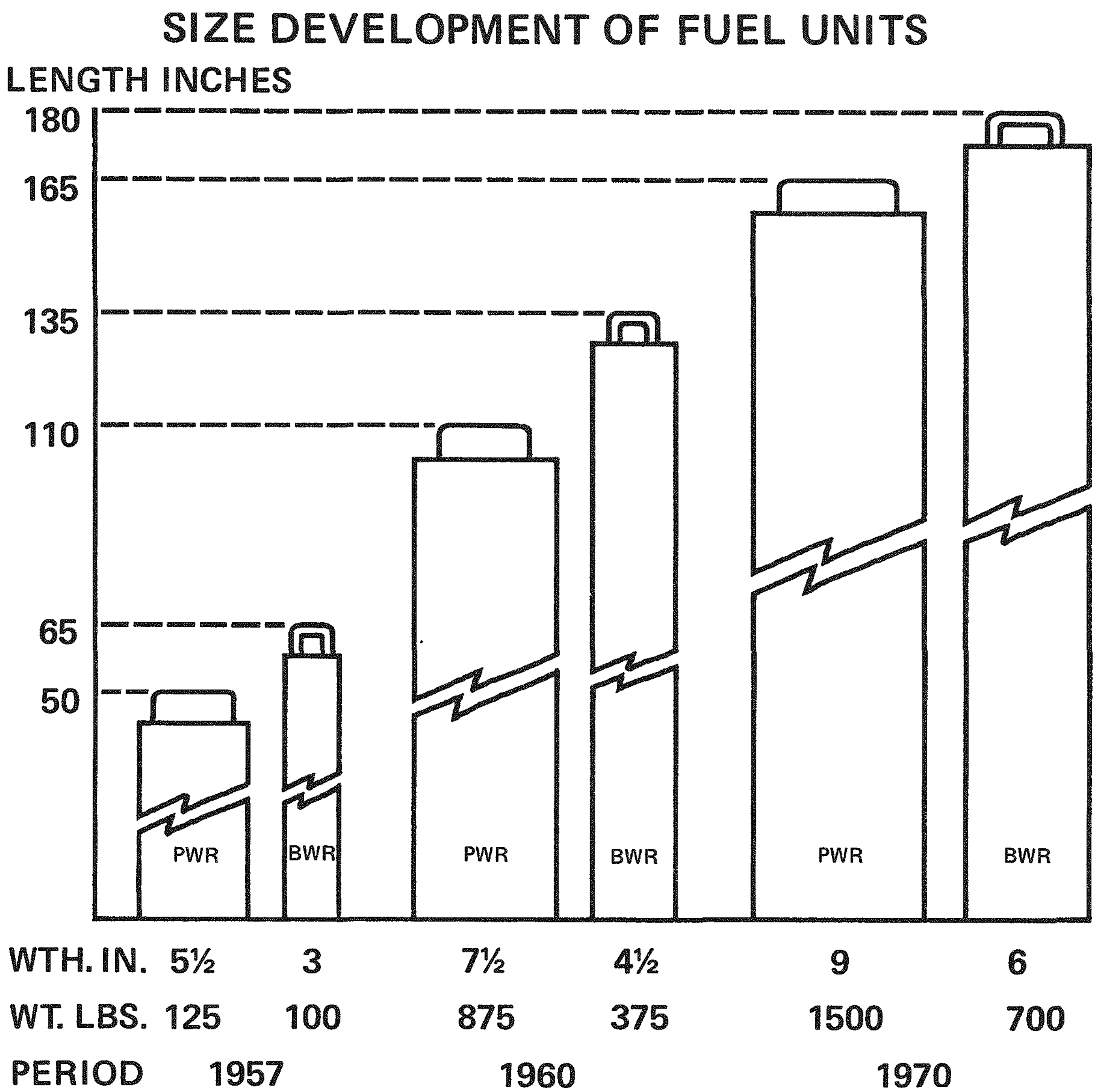

SIZE DEVELOPMENT OF FUEL UNITS
LENGTH INCHES
180
165
135
110
65
50
PWR
BWR
PWR
BWR
PWR
BWR
WTH. IN. 5½ 3 7½ 4½ 9 6
WT. LBS. 125 100 875 375 1500 700
PERIOD 1957 1960 1970

FIGURE 1.

SPENT FUEL AVAILABLE FOR SHIPMENT ASSUMING 1 MTU/LOAD

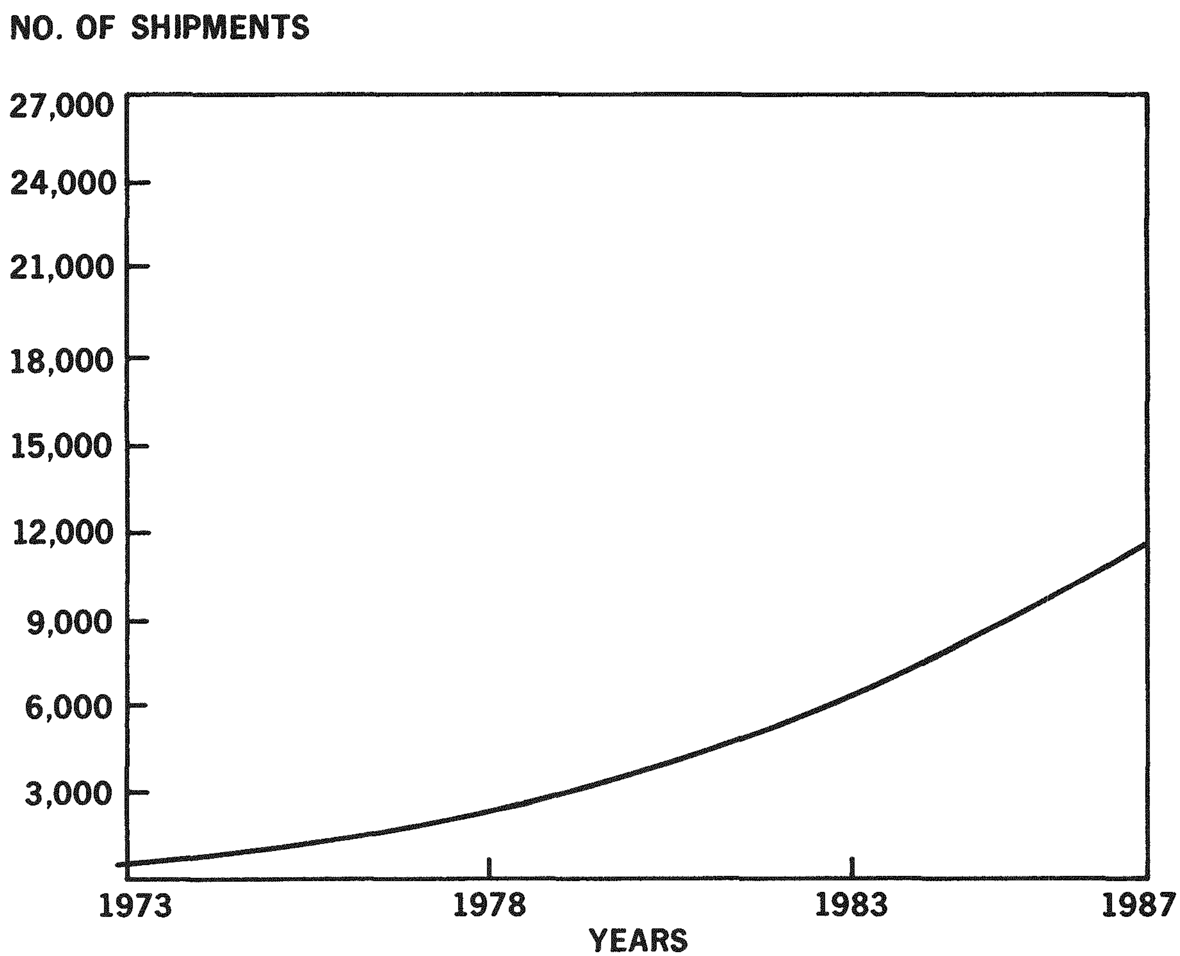


FIGURE 2.

DEVELOPMENT OF DOCUMENTATION FOR THE TRANSPORT OF RADIOACTIVE MATERIALS

J. Fairey

ABSTRACT

A documentation system has been developed to deal with the complexities of national and international movement of radioactive materials and the methods and forms used for this and the special requirements of fissile material movement are detailed.

INTRODUCTION

At Aldermaston the world-wide movement of some 1000 consignments a year consisting of over 12,000 packages of a great diversity of radioactive content, has led to the establishment of a system of documentation that may be of use to other installations. Experience has shown that it is essential for the person receiving the consignment to be aware of the form and packing of the contents, and in the case of fissile material, he needs to know this well in advance so that appropriate arrangements can be made. The system of documentation developed covers all these aspects as well as acting as an acceptable requisition for transport, accounting document and emergency information docket.

TRANSPORT MOVEMENT CONTROLLER

To operate the system and in view of the complexity of national and international regulations for the movement of radioactive materials by sea, road, rail and air in the UK and to other countries, the role of Official Consigner has been vested in the Transport Movement Controller whose main tasks are:

(a) To check the movement proposed is in accordance with the regulations.

(b) To make all transport arrangements and arrange where necessary.

(c) To arrange escorts and notification of moves to competent authorities and others where necessary.

(d) To assume the Consignor's responsibility for the load until it completes its journey.

This means that changes in regulations, package approvals and emergency arrangements can be fed to one focal point where the responsibility lies not only for handling the system but for disseminating the information about all aspects of it.

DOCUMENTATION

To achieve these various objectives a form of documentation has been developed which has resulted in the use of one form which covers all aspects on one sheet. This form is known as the MRA 1 (Movement Radioactive 1) and the main layout of this form is shown at Figure 1. It is in seven parts all of which are shown on the face of the document. A small guide has been produced to help consignors who are using the form for the first time. This guide also lists names of staff who can offer advice.

Consignment Requirements

Section 1, Figure 2

This includes the pick-up point and destination and request for transport, cranage and special instructions. There is also reference to fissile material clearances, and the need to obtain Health Physics certificates.

Package Details

Section 2, Figure 3

This is the most important section, and is designed to provide the Transport Movement Controller with the information he needs to check that the consignment is clear to go. It also helps individual consignors to think before they move. The wording complies with IAEA C.6.4.2. and gives full details of approval nos, contents, dose rate and in the case of fissile materials, information required in IAEA C.6.4.2.1 (i) and (ii), and allows for up to eight different types of package to be included.

Carriers Requirements

Section 3, Figure 3

This section covers labelling, toxicity group, transport index and allowable number.

Authorisation

Section 4, Figure 2

This is for the Transport Movement Controller's approval and insurance details.

Consignors Certificate

Section 5, Figure 3

This complies with IAEA C.6.4, and National Regulations.

Transport Identification

Section 6

This includes the drivers details and vehicle numbers.

Departure Record

Section 7

This gives departure date and time from the main gate of the establishment and provides the first link in the monitoring system for the journey.

Distribution

There are 4 copies of the carbon backed form used and these are dealt with as follows:-

No. 1 copy is used to request consideration and arrangement of the movement.

No. 2 clears the consignment through various stages on site and is retained at the departure point as the basis of the emergency procedures should the consignment be involved in an accident on route.

No. 3 is the delivery note that travels with the consignment to the consignee and can be used as a receipt.

No. 4 is the initiators copy for retention and can be used for accounting purposes.

FISSILE MATERIAL

For fissile materials an additional documentation system is necessary to ensure that a consignee is ready and able to accept fissile material without infringing his criticality clearance and to ensure that adequate safety arrangements are made. A system of pre-printed telex forms has been developed to meet this requirement as follows:

(a) The offer, Figure 4.

(b) The acceptance, Figure 5.

(c) The despatch note, Figure 6.

(d) The delivery note.

The offer is despatched to the consignee, and if he is able to receive he cables back the acceptance, with instructions on how, and where, and to whom it is to be delivered. We have learnt and are encouraging others that no moves should be contemplated until these 2 stages are complete. Considerable expense can be incurred if a verbal clearance is given for a consignment which on arrival can cause serious storage problems. The despatch advice confirms that the consignment is on the way and the delivery note travels with the goods as it would on a normal radioactive consignment. It is recommended that if adopted the system should not be unilaterally varied but for regular consignments of similar articles then a modification can be agreed by both parties.

This system was developed for general use in the UKAEA by a Working Party set up by the Authority Health and Safety Branch.

CONCLUSION

If some of these points appear obvious, experience has led us to believe that only by strict insistance on every point can the effects of the unplanned event when it occurs be minimised. Our packages have been subject to all degrees of event, from careless handling at airports to train crashes, and nearly always have taken place outside working hours, but with the information to hand expert advice has been swiftly given, and the consignment recovered, repacked if necessary and re-routed.

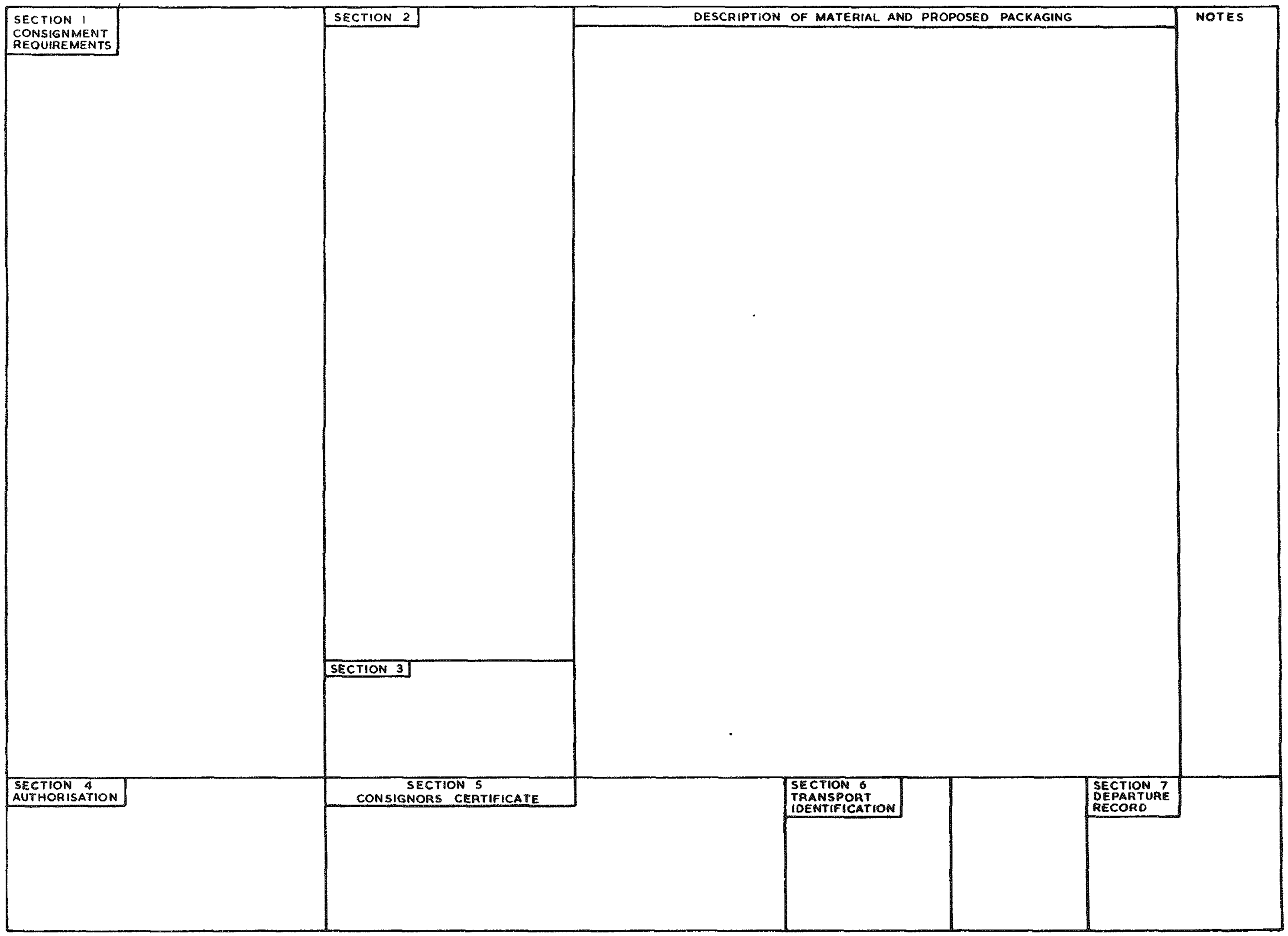


FIGURE 1. General Arrangement of Form MRA.1 (Movement Radioactive 1).

AWRE APPLICATION TO MOVE RADIOACTIVE/SPECIAL MATERIALS OFF SITE
IN ACCORDANCE WITH THE UK OR INTERNATIONAL REGULATIONS FOR TR

SECTION 1 CONSIGNMENT REQUIREMENTS	To be completed by the Consigning Officer please delete appropriate alternatives	SECTION 2

To Transport Movement Controller
CM Building A1 2 Tel Ext 5501

Please arrange the movement of radioactive/special materials detailed in Sections 1 and 2 of this application

From Mr Tel No

Pick up point including Building No where appropriate

To Mr Tel No

Destination including Building No where appropriate

The consignment will be ready for collection as from

hrs on (date)

The latest date for delivery is

Please provide TRANSPORT/CRANE/FORK LIFT TRUCK

Security Grading - Load

MRA 1

Please ensure the following special instructions are observed

I will provide written confirmation from the consignee that he is willing to accept the fissile material /large source /special arrangement specified in Section 2 before the vehicle(s) leave(s) the Establishment The package(s) will be properly labelled in accordance with the advice of the Transport Movement Controller and Health Physics Certificate(s) will have been obtained for each package prior to the vehicle(s) being loaded In the case of a designated full load a Health Physics Certificate will also be supplied for the entire load A Health Physics Certificate for the cab of the vehicle will be obtained at this loading point

Signed

Grade Tel No

Division/Branch

PACKAGE DETAILS
DESIGN N
EXTERNAL PACKAGE
TOTAL WI
WEIGHT (
ACTIVITY
DOSE RATES
mR/h AT
mR/h AT CENTRE C
INTERMEDIATE
DESIGN N
SERIAL N
INNER
DESIGN N
SERIAL N
RECEPTACLE
DESIGN N
SERIAL N
UNIQUE I
INSPECTION
EARLIEST
CONTENTS
MATERIAL
SOLID/LI
'SPECIAL
EXPLOSIV
ADDITIONAL INFORMA
MATERIAL, LARGE SOL
LARGE SC ARRANGE
HEAT OU
CRITICAL
RECEPTACLE
WEIGHT (
WEIGHT (
WEIGHT TO TOTAL
WEIGHT (
WEIGHT TO TOTAL
GRADE A CONTENT
WEIGHT TO TOTAL
WEIGHT TO TOTAL
SOLUTIO
SPECIAL I OF Be, C (
SECTION 3 TO B
TOXICITY
FISSILE C
ALLOWAI
TRANSPC
PACKAGE
TRANSIT PACKAGE

SECTION 4 AUTHORISATION	To be completed by the Transport Movement Controller	

COFS No
The packaging proposals are approved

Signed Date

Transport Movement Controller

This is to certify t *are properly desc* the Radioactive Regulations for tr the appropriate H by the consigne vehicle(s)

Signed

MRA ... MARCH 1970

FIGURE 2. Detailed Layout of Sections 1 and 4 of Form MRA.1

RIALS OFF SITE
LATIONS FOR TRANSPORT BY ROAD/RAIL/SEA/AIR/POST

SECTION 2 — To be completed by the Consigning Officer	No	DESCRIPTION		
PACKAGE DETAILS				
DESIGN No LETTER AND SERIAL No	1			
EXTERNAL DIMENSIONS OF PACKAGE (cm)	2			
TOTAL WEIGHT OF PACKAGE (kg)	3			
WEIGHT OF RA/SPEC MATERIALS (kg)	4			
ACTIVITY OF CONTENTS IN CURIES (Ci)	5			
DOSE RATES				
mR/h AT SURFACE	6			
mR/h AT ONE METRE FROM CENTRE OF PACKAGE	7			
INTERMEDIATE				
DESIGN No	8			
SERIAL No	9			
INNER				
DESIGN No	10			
SERIAL No	11			
RECEPTACLE				
DESIGN No OR DESCRIPTION	12			
SERIAL No	13			
UNIQUE IDENTITY No OF CONTENTS	14			
INSPECTION				
EARLIEST MAINTENANCE EXPIRY DATE	15			
CONTENTS				
MATERIALS BY NUCLIDES OR Be OR Zr	16			
SOLID/LIQUID/POWDER/GAS OR SPECIAL FORM	17			
EXPLOSIVE/PYROPHORIC	18			
ADDITIONAL INFORMATION REQUIRED FOR FISSILE MATERIAL LARGE SOURCES & SPECIAL ARRANGEMENTS				
LARGE SOURCE SPECIAL ARRANGEMENT IDENTITY MARK	19			
HEAT OUTPUT IN WATTS	20			
CRITICALITY CLEARANCE No	21			
RECEPTACLE (S)				
WEIGHT OF TOTAL U CONTENT (kg)	22			
WEIGHT OF 233 U CONTENT (kg)	23			
WEIGHT / 233 U WITH RESPECT TO TOTAL U	24			
WEIGHT OF 235 U CONTENT (kg)	25			
WEIGHT / 235 U WITH RESPECT TO TOTAL U	26			
GRADE AND WEIGHT OF TOTAL Pu CONTENT (kg)	27			
WEIGHT / 240 Pu WITH RESPECT TO TOTAL Pu	28			
WEIGHT / 241 Pu WITH RESPECT TO TOTAL Pu	29			
SOLUTION CONCENTRATION (g/dm3)	30			
SPECIAL FEATURES eg PRESENCE OF Be C OR D_2O	31			
SECTION 3 TO BE COMPLETED BY TMC				
TOXICITY GROUP (S)	32			
FISSILE CLASS	33			
ALLOWABLE NUMBER	34			
TRANSPORT INDEX	35			
PACKAGE TYPE	36			
TRANSITORY LABELS FOR OUTER PACKAGE	37			

SECTION 5
CONSIGNOR S CERTIFICATE — To be completed by the Consigning Officer after loading — TR/

This is to certify that the above named goods listed on sheet(s) one to herewith are properly described and are packed and marked in accordance with the applicable provisions of the Radioactive Substances (carriage by road) (Great Britain) Regulations or of the International Regulations for transport by road/rail/sea/air/post and are in proper condition for transport I hold the appropriate Health Physics Certificate(s) for the package(s) I attach copies for use en route and by the consignee and a Health Physics Certificate for the cab(s) of the vehicle(s) or the entire vehicle(s)

Signed Grade Date

FIGURE 3. Detailed Layout of Sections 2, 3 and 5 of Form MRA.1

OUTGOING TELEX	Precedence	OPS. USE ONLY Serial No. Date/Time

TO

RPT

RPT

RPT

RPT

FROM TEL. EXT.

FMT 1 CONSIGNMENT REF

PROPOSE CONSIGN

FROM

TO

BY ON OR ABOUT

CONSIGNEE ACCEPTANCE REQUESTED

Date	Signature	Branch	Building

FMT 1

FIGURE 4. Fissile Material Telex 1 (FMT 1).

OUTGOING TELEX	Precedence	OPS USE ONLY Serial No. Date/Time

TO

RPT

RPT

RPT

RPT

FROM TEL. EXT.

FMT 2. YOUR FMT 1 OF

PERMISSION TO DESPATCH CONSIGNMENT REF.

COMPRISING

GIVEN BY

CONSIGN TO BLDG. NO.

SPECIAL CONDITIONS ARE

Date	Signature	Branch	Building

FMT 2

FIGURE 5. Fissile Material Telex 2 (FMT 2).

OUTGOING TELEX | Precedence | OPS USE ONLY
Serial No
Date/Time

TO

RPT

RPT

RPT

RPT

FROM TEL. EXT.

FMT 3. CONSIGNMENT REF.

COMPRISING

FOLLOWING PACKAGES BEING DESPATCHED

BY

ON ETA NMTC No.

PACKAGE IDENTIFICATION NO.	MATERIAL	NET BULK WT	FISSILE CLASS	ACTIVITY	TRANSPORT INDEX

Date	Signature	Branch	Building

FMT 3

FIGURE 6. Fissile Material Telex 3 (FMT 3)

METHODS USED TO CALCULATE PACKAGE CRITICALITY SAFETY

W. T. Mee

ABSTRACT

Methods used to analyze the criticality safety of packages for shipping fissile material must satisfy both technical and economic criteria. The primary technical criterion to be satisfied is that a method must be validated for its proposed use. For numerous reasons, not the least of which are the conditions of package environment which must be assumed in analyses according to USAEC and IAEA transport regulations, such a validation may be a complicated procedure. Economic criteria which must be satisfied can be the most difficult to establish because of the complex interrelationships between the costs of analysis, packing, and transportation.

Several methods of analysis in current use, including solid angle, NB_N^2, and transport theory calculations, are used to satisfy these criteria. In this presentation, examples of the various methods are delineated. Transport indices for the examples have been calculated, and some are presented in graphical rather than tabular form to allow for increased flexibility in using the packages.

INTRODUCTION

Unirradiated fissile materials have been shipped by all modes of transportation for over a quarter of a century without a reported criticality incident. Such a record cannot be improved upon, but it can be destroyed unless the same diligence for nuclear criticality safety is maintained by responsible Nuclear Criticality Safety personnel. During this history-making safety record, the number of methods used to analyze these shipments is probably equal to the number of personnel performing the analyses. This condition certainly existed prior to the introduction of formal regulations in the early 1960s. The major change resulting from the regulations is the provision of package testing criteria for evaluating package stability and guidelines for criticality safety analysis.

REGULATIONS

The regulations introduced within the last decade consist of: the IAEA Safety Series,[1] the USAEC Manual Chapter 0529,[2] and the USAEC Title 10, Part 71.[3] These regulations establish the criteria for physically testing the packages both for normal and accident conditions. In addition, they establish the basis for determining the limits on the number of packages that may be shipped for the three classes of shipments. They do not establish or restrict the methods of analysis for deriving the criticality of a package array or the number of packages that are critically safe for the actual permitted shipment. This responsibility remains with the Nuclear Criticality Safety Specialist.

METHODS OF ANALYSIS

The available means to resolve package criticality safety may be categorized as experimental comparisons and calculational programs. If direct experimental data are available, the solution is straightforward by direct comparison. However, if extrapolations or interpolations of experimental data are required, the need arises for validation of the assumptions and conclusions. These assumptions may pertain to the fissile masses and geometries, the amount of separation between units, the reliability of extrapolating to larger arrays, and/or the effect of moderation and reflection. In other words, it must be assured that the conclusions resulting from all, or part, of these assumptions associated with interpreting experimental data are correct and reproducible within acceptable limits.

The category of calculational applications is not less stringent on the Nuclear Criticality Safety Specialist. In choosing the calculational approach to resolving package criticality safety, a choice may be made from many available systems. Selection must be done carefully to ensure that the chosen method is applicable to the problem at hand. There are a number of documented systems which have been used for package criticality safety analysis. Among them are GEM, KENO, Density Analog, NB_N^2, and Solid Angle. All have proven satisfactory for selected applications. To repeat, it remains incumbent on the specialist to choose the system to be used for the specific package analysis and to assure that its result satisfies nuclear criticality safety.

In any calculational program, it must be recognized, as Crume stated at the 1968 Second International Symposium held at Gatlinburg, Tennessee, "that the accuracy of the calculational method in calculations of the criticality conditions of systems depends not only on how well it solves the equation of neutron transport, but also on the neutron interaction cross sections that are used. The only way to check the combination of a program and a set of cross sections for accuracy is to calculate experimentally measured systems and compare the results."[4]

Therefore, regardless of the method chosen, whether it be calculational or experimental (unless the experiment is for the actual conditions of the proposed package), validation is an absolute necessity to satisfy the nuclear criticality safety.

ECONOMICS

Economic considerations are an integral part of package nuclear criticality safety evaluations. Considerations affecting the costs are: cost of criticality safety analyses, package fabrication, and transport. All of these costs are interrelated, and to attempt a savings in one may cause an increase in the overall costs. Thus, coordination of these interrelated costs becomes a necessity to ship fissile materials in packages that are critically safe yet economical. In an attempt to better define this consideration and unravel some of the complexities of costs, consider the three individual effects as follows:

Analysis Costs

A balance of effort must be attained that will provide the needed result at minimum total cost. This goal means that ultra conservatisms should be avoided as well as the extensive analytical efforts which produce little improvements over less costly but acceptable solutions.

Fabrication Costs

The cost of package fabrication may be relatively insignificant or very expensive. Such factors as the materials of construction used, the use of standard or nonstandard containers, or over emphasis on the amount of protection needed for off-site shipments, are influential on the overall cost. Obviously, the package designers and fabricators must work very closely with the Nuclear Criticality Safety Specialist to achieve maximum safety with minimum cost.

Transportation Costs

The cost to transport the packages is directly related to the nuclear criticality safety analysis. As an example, if the analysis is ultra conservative, too few packages may be shipped in one vehicle, resulting in increased freight costs.

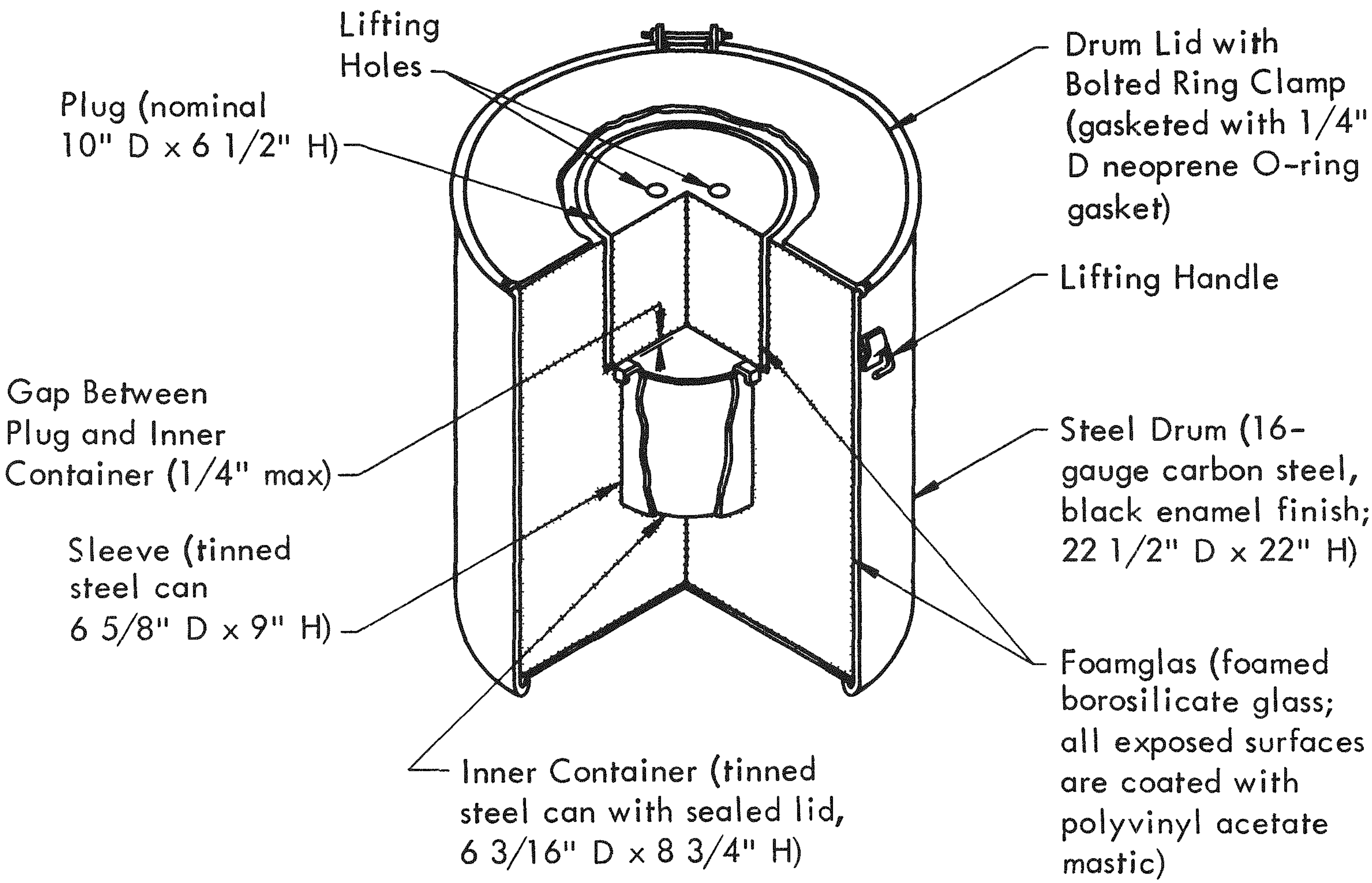
EXAMPLES OF PACKAGE CRITICALITY SAFETY ANALYSES

The Y-12 Foamglas Shipping Container illustrates a package for the safe shipment of enriched uranium at a relatively inexpensive cost. Figure 1 presents a schematic view of this container. The outer containment vessel is a 55-gallon-type drum of type 17 H specifications reduced in length to 22 inches. The filler material between the outer and inner containers is Foamglas (a by-product from the manufacturers of Pyrex-type glass.) An open top, flanged, tinned-steel can is positioned in the center of the Foamglas to hold the containment vessel. The containment vessel is a tinned-steel, one-gallon-capacity can with a sealed lid. All of these materials are standard items that may be purchased on the open market.

Physical testing of this package was performed under the criteria of AECM-0529 and was reported by McLendon in 1962.[5] It was concluded from these results that the package did not suffer sufficient damage to alter the basic assumptions of spacing and containment. Therefore, the analyses were made using the undamaged package arrays. Thus, the analysis for nuclear criticality safety of the shipments was required to show that five such shipments would be safe if accumulated in a cubic array as per the regulation criteria.

Calculational Analyses

Table 1 summarizes the results of three calculational methods to determine the safe number of Y-12 Foamglas packages containing up to 19 kilograms of ^{235}U metal of any enrichment that may be shipped as Fissile Class II.



Neg Y-140760

FIGURE 1. Y-12 Foamglas Shipping Container.

Table 1. Comparison of Methods for Assigning a Fissile Class II Transport Index to the Y-12 Foamglas Container to Carry Nineteen Kilograms of ^{235}U Dry Metal

Condition	Solid Angle	NB_N^2 (1/8-Inch Steel)	NB_N^2 (12% Less Mass)	KENO Code
Number of Spheres in Critical Bare Cubic Array	18500			
Number of Spheres in Critical Reflected Cubic Array	617	420	280[1]	
Number of Spheres in Critical Reflected and Optimumly Moderated Cubic Array	308	420[2]	280	
Safe Number of Packages	308[3]	420[3]	280[3]	512[4]
Safe Number of Packages Divided by 5	61	84	56	102
Transport Index	0.9	0.6	0.9	0.5

(1) A 21.59 kilogram U(100) metal sphere was considered by this method in order to ship 19 kilograms.

(2) One-eighth inch of steel around each unit mass is sufficient to maintain subcriticality with the presence of optimum interspersed water moderation.

(3) Insertion of package materials provides less than optimum moderation.

(4) $k_{eff} \pm = 0.94 \pm 0.01$.

Each method described in the sections that follow illustrates the exercises that are necessary to determine the safe number of packages permitted to be shipped. These analyses assume that the units are arranged in as near a cubic array as the package dimensions permit (i.e., the array H/D = 1.)

Solid-Angle Method

The solid-angle method[6] involves calculating the unreflected array size, reduced by a factor of 30 for a full-water reflector that surrounds the array. Thomas has reported that the reflection factor for large, unreflected arrays of metal units to be this order of magnitude.[7] A further reduction in array size of 50 percent is applied to the reflected array to compensate for moderation. The 50 percent reduction is sufficient for metal units where optimum interspersed moderation will not produce criticality.

NB_N^2 Method

The NB_N^2 method[7] is illustrated by two approaches. The first approach considers the metal unit without any neutron absorber surrounding it; whereas, the second approach demonstrates the effect of having a 1/8-inch-thick steel containment vessel surrounding the fissile material. Both analyses eliminate the evaluation of the bare array; however, in the first case a 12 percent reduction in unit mass to compensate for the presence of interspersed hydrogenous moderation has to be applied, as reported by Thomas.[8] Therefore, if the maximum mass to be shipped is 19 kilograms of ^{235}U, a 21.59-kilogram unit mass must be analyzed to determine the safe number of packages. In the second analysis, the tinned-steel "tomato" can is replaced with a steel can having a minimum wall thickness of 1/8 inch. In this case the number of steel-surrounded units critical for moderated and reflected conditions is identical to the number critical with array reflection only - no steel and no moderation. This result is substantiated by Thomas who has reported that individual units of fissile materials surrounded by a minimum of 1/8-inch of steel in an array is sufficient to maintain subcriticality independent of the amount and distribution of interspersed hydrogenous moderation present.[9] Therefore, if the containment vessel were made with 1/8-inch steel, a larger number of packages would be permitted to be shipped by this method over the as-built condition.

Keno Method

The third method illustrates the use of a multigroup Monte Carlo criticality program identified as KENO.[10] Since KENO permits the package to be realistically described and will produce a k_{eff} of the array, the safe array for the prescribed conditions can be directly calculated. This approach obviously has required the development of a high confidence level and, further, it has required a stringent determination of the upper limit of the k_{eff} of a system. Y-12 personnel believe that this method is more realistic for calculating the actual conditions and have developed a confidence level through validation procedures. It has been established that an upper limit of $k_{eff} + 2\sigma = 0.97$ for a critical condition is conservative when compared to experimental data. Thus, if the calculational search is made for optimum package conditions with the restriction that $k_{eff} + 2\sigma$ must be less than 0.97, the resultant array size satisfies the regulation criteria.

Safe Number of Packages

Referring again to Table 1, it is to be noted that the safe number of packages in each of the first three columns is the same as that for the number that are critical for reflected and optimumly moderated cubic arrays. This condition exists since the critical array was considered without the package itself being a part of the array, whereas the insertion of the package around each metal unit decreases the reactivity of the array. This effect is attributed to the materials of the package. Specifically, the boron in the Foamglas has been shown to be a sufficient neutron absorber to reduce the optimumly moderated critical array to a subcritical condition.

Once the safe-array size of the packages is determined, the number is divided by 5 to satisfy the regulation criteria for the maximum number of packages per shipment. The resultant number is then divided into 50 to determine the transport index for each package in the shipment. The additional restriction on the transport index which may reduce the number of packages per shipment is that all fractions must be rounded upward to the nearest tenth (i.e., 0.11 becomes 0.2.)

As illustrated, any of these three methods would allow the Nuclear Criticality Safety Specialist to develop a package which would meet the regulatory criteria and satisfy the condition of being nuclear criticality safe. However, as shown, the method chosen may or may not allow the largest number of packages to be shipped as Fissile Class II. Of course, if more than one method is used and two different answers result, the specialist would be prone to use the one which gives the smallest number of packages for criticality safety. However, realistic considerations must be made to assure that the choice made does not impose undue restrictions.

PACKAGE UTILIZATION

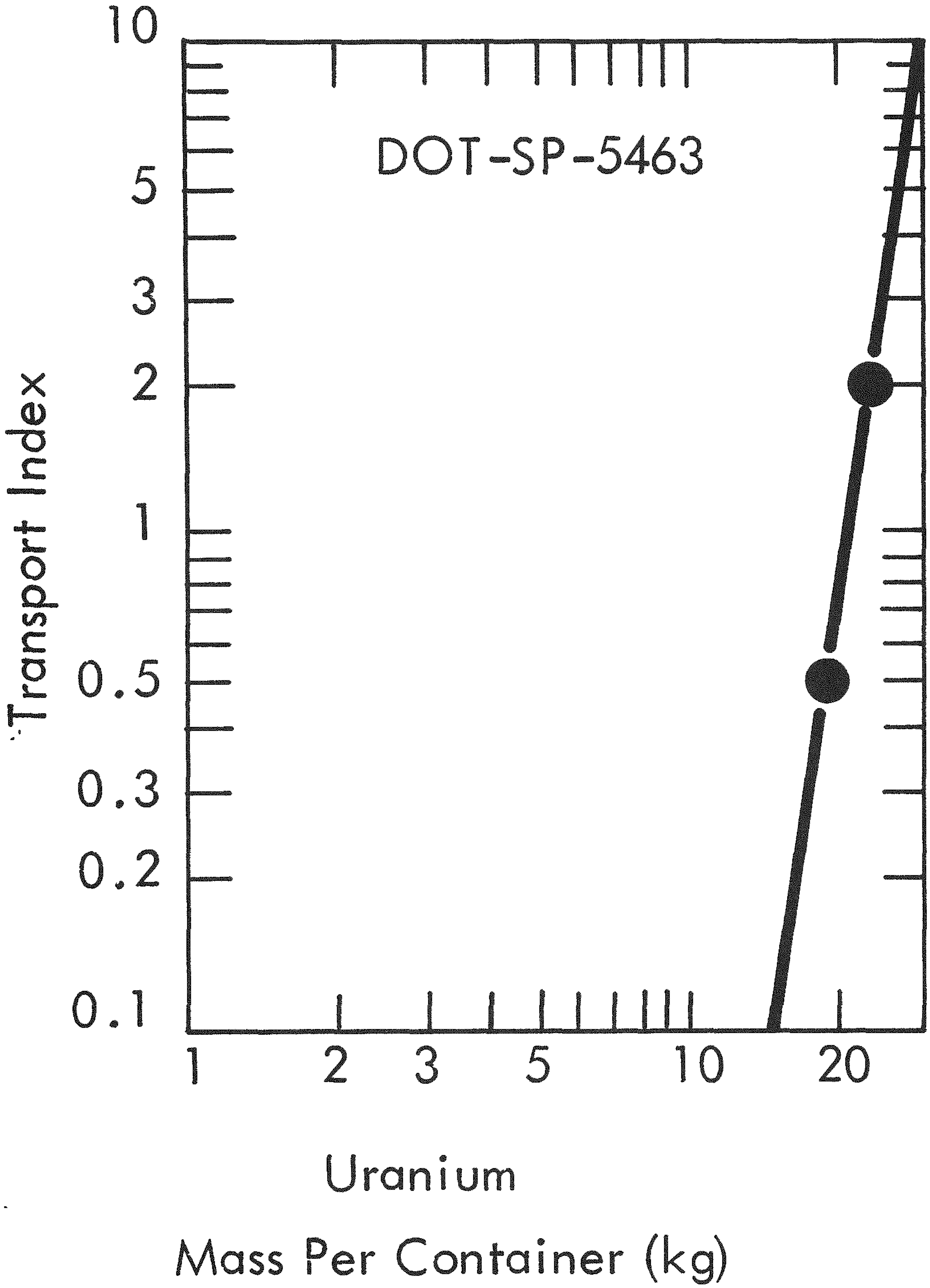
Maximum flexibility in the use of packages for transporting fissile materials should be provided. Figure 2 shows a curve of the transport index versus the mass of enriched uranium metal per package for the Y-12 Foamglas Container as determined by the KENO method discussed. Calculations in addition to the one shown in Table 1 were necessary to develop the curves. Such an arrangement permits process personnel more use of the package. This graphic illustration emphasizes the need to utilize the best possible method for the analysis without undue conservatism, and to recognize influences on the overall costs.

CONCLUSIONS

In conclusion, the Nuclear Criticality Safety Specialist responsible for evaluating packages for the transport of fissile materials has numerous methods available to satisfy the regulatory requirements and criticality safety rules.

To determine the degree of package criticality safety, the Nuclear Criticality Specialist must:

1. Choose a method that is well validated for the system to be analyzed.
2. Work closely with the package fabricators to ensure an understanding of the materials of construction which will permit a realistic analysis.
3. Participate in or be well informed of the results of the physical testing of the package.
4. Incorporate as much flexibility in the analyses as possible to allow process personnel to meet their commitments, yet maintain nuclear criticality safety with minimum costs.



Neg Y-140761

FIGURE 2. Transport Index Versus the Urnaium Mass per Y-12 Foamglas Container.

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A CALCULATIVE METHOD FOR DETERMINING EFFECTS OF THE 30-MINUTE FIRE ON LEAD SHIELDED CASKS

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R. H. Odegaarden**

ABSTRACT

A study was made to develop a framework of data which could be used to predict the thermal effects of the prescribed 30-minute fire on lead filled casks once certain specific design parameters of the package are known. The study utilized a two-dimensional transient heat conduction program (ORTHAT) which handles the cylindrical geometry of shipping casks used to transport irradiated fuel elements. The radial and axial thickness of the lead and outer steel shell were varied along with the cavity size. Both finned and unfinned stainless steel and unfinned mild steel outer shells were considered. In order to examine the effects of possible convection within the molten lead, the thermal conductivity of the lead was arbitrarily doubled in some cases. The data show that the melting-front can be restricted if the outer surface of the cask is properly finned. Furthermore, the presence of voids at the cask corners would reduce the amount of lead that will melt.

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INTRODUCTION

With the general acceptance by electrical utilities of large central nuclear power plants as an economical means of supplying electrical power, numerous related activities such as fuel fabrication, fuel reprocessing and transportation have developed to complete the nuclear cycle. In keeping with government policy and regulations these nuclear age activities must be given a safety evaluation commensurate with their potential hazards. This paper is limited to an assessment of the effects of the prescribed 30-minute 1475°F fire on lead filled casks designed to transport irradiated nuclear fuel. A range of parameters was selected which would provide information for future cask designers or users to quantitatively determine the effects of such a fire on their package design. The 30-minute fire requirement is specified in AEC and DOT regulations.

CALCULATIONAL PROGRAM

The computer program used in this study was ORTHAT[1], which was developed to solve transient heat conduction problems in two-dimensional geometries, in particular problems associated with the design of irradiated fuel shipping casks. Thermal properties, heat generation rates, and boundary conditions can be expressed as functions of position, time, or temperature. The program uses a modified alternating-direction implicit method (ADI) to solve the transient problem. The input for the program is an easily usable free-form style. The program includes an approximate treatment of nodal melting and freezing of the lead. The output from the program is in a map-like framework which makes it easy to see the temperature distribution as a function of time. The calculated values are the center temperatures for each equal volume node in a given region.

In our evaluations, advantage of the code's ability to take into account both radiation and natural convection at the outer surfaces of the casks was utilized. The external temperature and the natural convection coefficient were varied in order to describe both the fire and cool-down phases.

The running time for each of the 58 cases on an IBM 370/165 computer was 14.35 minutes which included both the 30-minute fire and a 30-minute cool-down period following the fire. The running time could have been reduced if the time steps had been varied instead of maintaining a constant 10-second time step throughout each step of the problem. In addition, the running time was significantly lengthened since each of the lead nodes, which made up most of the 620 nodes, had to be checked for melting or freezing during each time step.

Temperatures calculated with the ORTHAT program have been compared with temperatures calculated with the HEATING3[2] program for an identical problem. The results did not differ at any node by more than 1 or 2 degrees. The HEATING3 program uses an explicit method to solve the transient calculations.

TYPES OF CASK MODELS SELECTED

All casks considered were right circular cylinders which were described by an R-Z geometry. The various shipping cask configurations included those with height to diameter ratios (H/D) ranging from one to four and wall thicknesses from 6 to 10 inches of lead. The axial thicknesses of lead ranged from 5 to 9 inches. In all cases the inner steel liner was taken to be 0.5 inch thick. The outer steel liner thickness ranged from 0.5 to 4 inches. Cask cavities were selected with 20-inch ID's by 26 or 130-inch lengths and, 36-inch ID's by 130 inches long.

BOUNDARY CONDITIONS

In the analysis of the effects of the 30-minute fire on the cask, symmetry was utilized at the center line and at the axial midpoint. The temperature of the cask, prior to the fire, was assumed to be 130°F. The boundary conditions at the inner and outer surfaces of the casks were selected based on the following reasons:

Inner Surface

The temperature of the cask inner surface is affected by the heat generation of the irradiated fuel and whether or not a liquid coolant such as water is present. In order to simplify our analysis and provide results representative of the maximum expected temperatures during the fire, we assumed the inner surface to act adiabatically. Based on this assumption, the calculated inner surface temperature as a function of time can then be used to ascertain the effects of the fire transient on the fuel and coolant. For example, if the cask were initially dry, the maximum fuel temperature increase would be approximately equal to or slightly less than the increase in the inner surface temperature. For a cask containing a water coolant, the inner surface temperature history could be utilized not only to calculate an upper limit fuel temperature, but also to determine if there is adequate pressure relief capacity for the cask. For example, knowing the maximum inner surface temperature, the boil-off rate of the coolant could be checked against the flow-ΔP rating for the pressure relief valve on the cask. The inner surface temperature histories for several cask geometries are presented in Figure 1.

Outer Surface

The boundary conditions applicable to the outer surface are in most part defined by 10 CFR Part 71 in that the emissivity of the fire is stated to be $\varepsilon = 0.90$ and the absorptivity of the cask surface to be $\alpha = 0.80$. Utilizing these prescribed radiation factors, the heat transfer at the outer surface of a bare cask, i.e., no fins, is trivial since the heat flux absorbed on the surface can be calculated using the product of these values, namely $\alpha\varepsilon = 0.72$. However, if the outer surface of the cask has heat transfer fins to improve the heat dissipation capabilities of the cask during normal operation, the heat transfer equation describing the net heat flow at the outer surface is quite different. For example, for a bare surface with an $\alpha = 0.80$, 80% of the impinging radiant energy is absorbed and 20% reflected. However, for a finned surface there is a probability that the reflected radiation (20%) will be incident upon another fin surface where a further 80% of its intensity is absorbed, to make a total of 80% + (.80 x 20%) = 96% absorbed after two reflections. It is therefore clear that the presence of fins could increase the proportion of incident radiation absorbed, the importance of this effect being greatest when α is low. Detailed consideration of this situation has been carried out (Reference 3) resulting in a determination of an effective emissivity (ε_c) for a finned surface. This work resulted in what is called the "optical" formula, namely $\varepsilon_c = [1.0 + \frac{d}{d + 2L} (\frac{1}{e} - 1)]^{-1}$, where d is the width and L is the depth of the fin. This equation has been used by numerous analysts over the past few years to predict the effect of the fins. The result has always been to predict a higher absorbed heat flux than the usual $\alpha\varepsilon T^4$ expression which is theoretically correct when predicting the heat input into a bare surface. Because the inherent assumptions in the "optical" equation make it valid only for small temperature gradients in the fin, i.e., low heat fluxes or high thermal conductivity for the fin material, our analysis for stainless steel fins utilized the work presented in Reference 4 which takes into account temperature gradients. The results of this work in Reference 4 are based on the fact that any point in the fire environment has only a restricted view of the cask surface, much of the view being taken up by the fins. Since these fins are at a higher temperature than the cask surface, the fire therefore sees an effective surface which is hotter than the cask surface itself. This in turn tends to reduce the net heat input into the fins, especially if α is high and the thermal conductivity of the fin is low. What this means is that we have two opposing effects, one improving heat transfer into the cask and the other, i.e., increased surface area, improving the heat transfer to the ambient. The net effect is a complex function of the geometry, thermal conductivity, etc. of the cask and fins.

With this situation in mind, we selected a single stainless steel axial fin whose dimensions appeared typical, and used it throughout our analysis. The dimensions of the fins chosen were length = 10 cm, thickness = 1 cm and pitch = 5 cm. Using these dimensions, and the data in Reference 4, we found the factor, R, which represents the ratio of the heat into a finned surface to that into an unfinned surface, of 0.77 for the stainless steel fins.

DISCUSSION OF RESULTS

The most significant result from this study is that detailed temperature and melt-front profiles for various cask designs have been obtained. These data can greatly facilitate the work of a designer in the conceptual stages of design by shedding some light on some very basic questions affecting the final design. For example, the total fuel inventory may not be entirely governed by the shielding, criticality or normal thermal considerations, but by the fuel temperatures attained as a result of increased cask inner wall temperatures following cessation of the fire. In the following paragraphs, a discussion is presented of the temperature and melt-front profiles in terms of cask geometry, presence of heat transfer fins, and the effect of possible thermal convection in the molten lead.

Temperature distribution at inner wall - The upper curve in Figure 1 represents the results for a cask with an H/D $\approx$ 4, and a 6-inch lead wall sandwiched between 1/2-inch thick inner and outer stainless steel shells. For this H/D size cask, it is noted that the inner wall temperature is roughly 10 to 20°F below the temperature attained for a cask with an H/D = 1.0 (See Table 1, Designs 2 and 3). Based on this small temperature difference it appears that the maximum inner wall temperature is not very strongly affected by its H/D ratio. The three other curves in Figure 1 represent data which show the effects of increasing the thicknesses of the lead and outer steel walls from 5 to 9 and 0.5 to 5 inches, respectively, for the radial and axial regions of the cask body. The maximum spread between any two of these bottom curves is $\approx$ 100°F, which is a quantity that could be important in the design of the cask if it were shown that the calculated fuel temperatures during the fire were approaching values where failure could occur. What also appears significant is that these inner wall temperatures remain at their maximum value for some time after the fire has been extinguished. In certain situations, this time-temperature combination could be important if fuel

Table 1. Maximum Inner Steel Shell Temperature (°F)

Cask Design Shown In Figure No.	No Fins S.S. Shell	No Fins Mild Steel Shell	Fins (S.S.) K_ℓ(Pb) = 9.2 Btu/hr-ft-°F	Fins (S.S.) K_ℓ(Pb) = 18.0 Btu/hr-ft-°F
2	620	620	606	608
3	620	620	585	584
4	619	620	572	573
5	618	620	567	567
6	542	548	453	453
7	506	514	422	422
8	516	518	436	436
9	431	441	362	362
10	515	517	435	435
11	479	480	406	406
12	479	480	406	406
13	458	466	383	383
14	431	441	362	362
15	431	440	362	362

failure could occur due to high temperature creep. Figure 1 does not contain the results for shipping casks containing exterior fins; however, a review of our data shown in Table 1 shows that temperatures for finned casks of comparable design to the casks represented by the middle two curves would be displaced downward at their peaks by as much as $\approx$ 75°F.

Melt-Front Profile - The majority of the data for melt-front distributions are self-explanatory, as can be easily seen from Figures 2 through 15. The melt-front figures show the locus of solid nodes. All nodes of 620°F or more were considered molten and are represented above and to the right of the curve. These data make it quite apparent that the stainless steel fins have the important effect of reducing the extent of lead melting. As previously explained, this is due to the fact that the cask outer surface will radiate more heat to the environs than a bare cask since its fin tips are hotter, especially when α is high and the thermal conductivity of the fin is low. Another interesting question which has been at least partially answered is whether or not convection in the molten lead will substantially affect the total weight of lead melted. From the Figures 2-15, the results of liquid lead convection are plotted using an effective thermal conductivity obtained by arbitrarily increasing the thermal conductivity of the molten lead from 9.2 to 18 Btu/hr-ft-°F. One further point of interest is the effect that void spaces at the corners of the cask could have on the amount of lead melting. This practice has been used by many cask designers to provide the additional expansion space needed when the lead changed phase. From our data, it appears that providing such voids not only would provide space for this phase change expansion, but also could substantially reduce the overall amount of lead melted during the fire. This is obviously so, since the void would act as an insulating barrier in the regions of maximum heat input into the cask, i.e., corners receive heat two-dimensionally. In conclusion, data show that the melting-front can be restricted if the outer surface of the cask contains fins with the proper pitch, thickness and material properties. Furthermore, the presence of voids at the cask corners would reduce the amount of lead that will melt.

ACKNOWLEDGEMENT

The authors are indebted to Mr. Richard Durfee of ORNL for making the ORTHAT computer program available to us for running these calculations. Mr. Durfee set up the first problem and patiently advised us on the use of the program. In addition, Mr. Moshe Siman-Tov of ORNL set up and ran the sample problem on HEATING3 as a check on the ORTHAT program.

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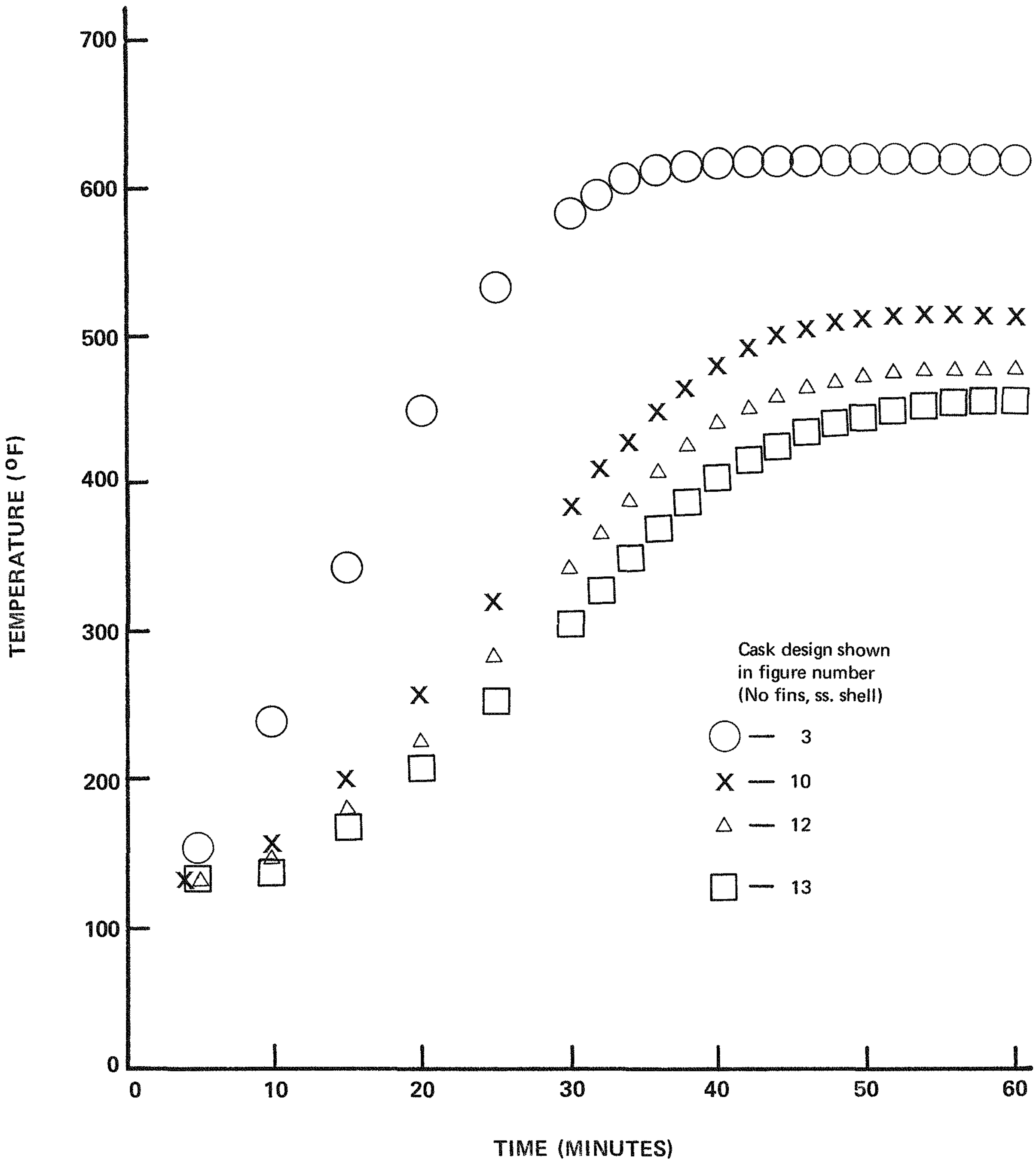


Figure 1. Inner Steel Shell Temperature.

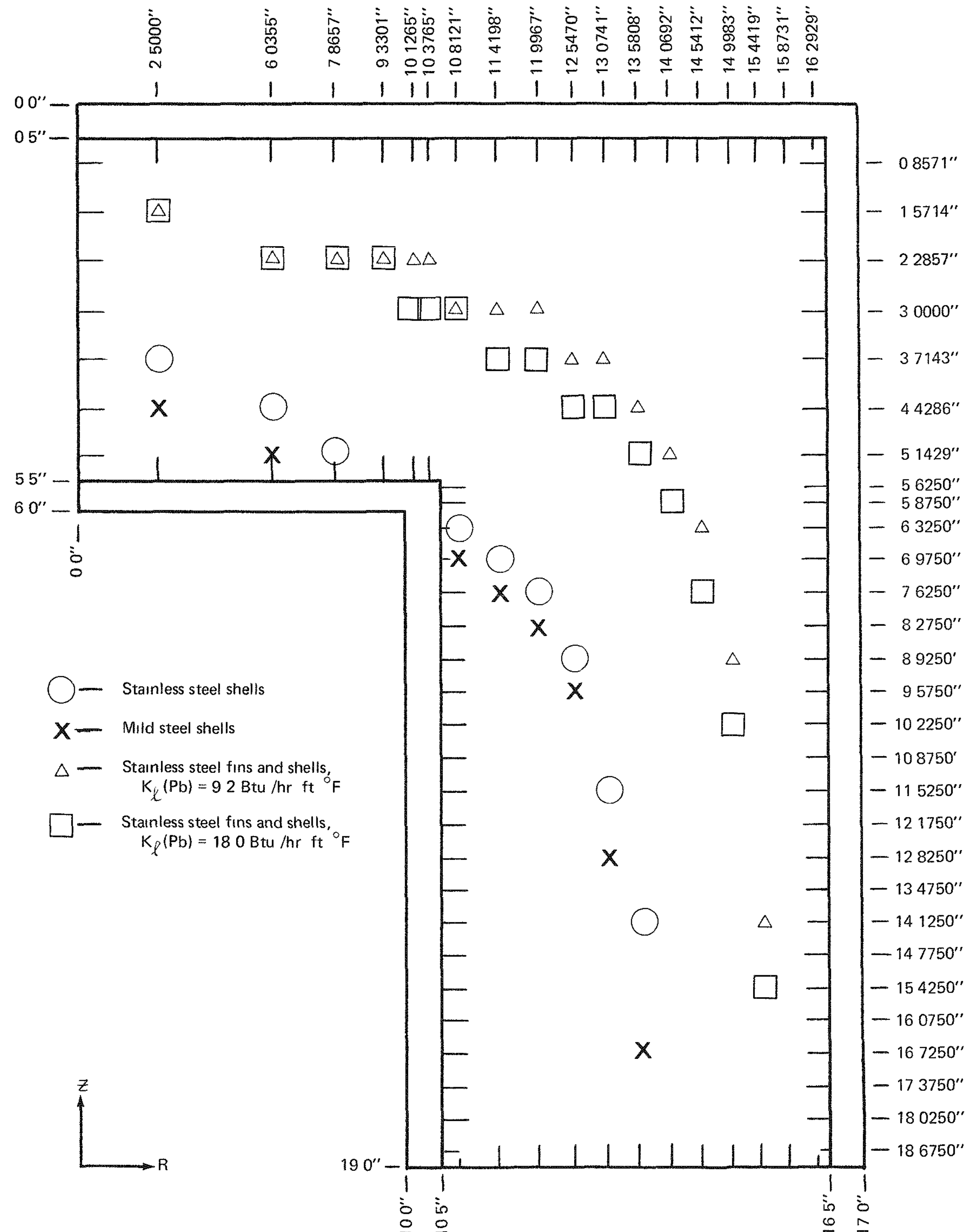
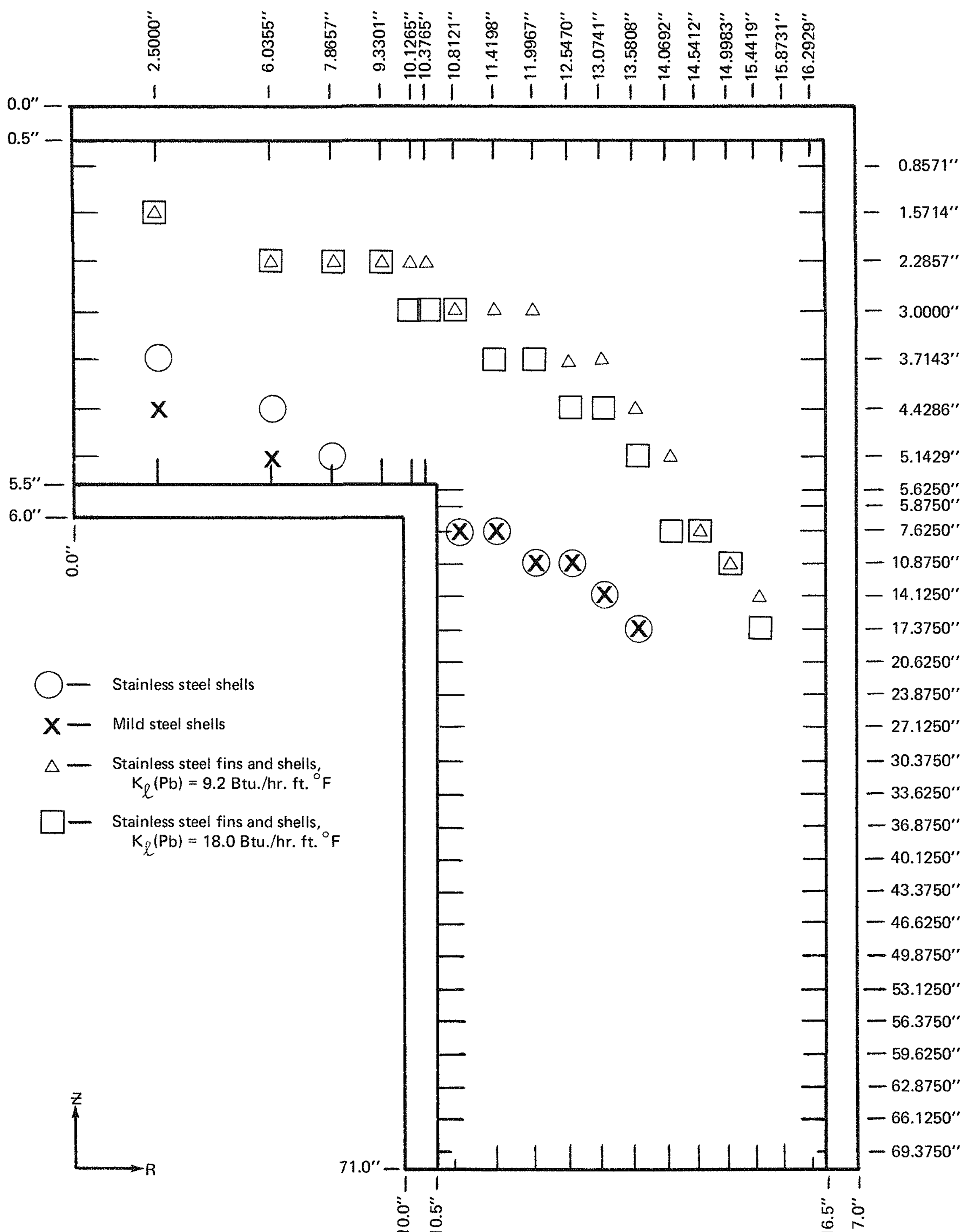


Figure 2. Melt Front Distributions.



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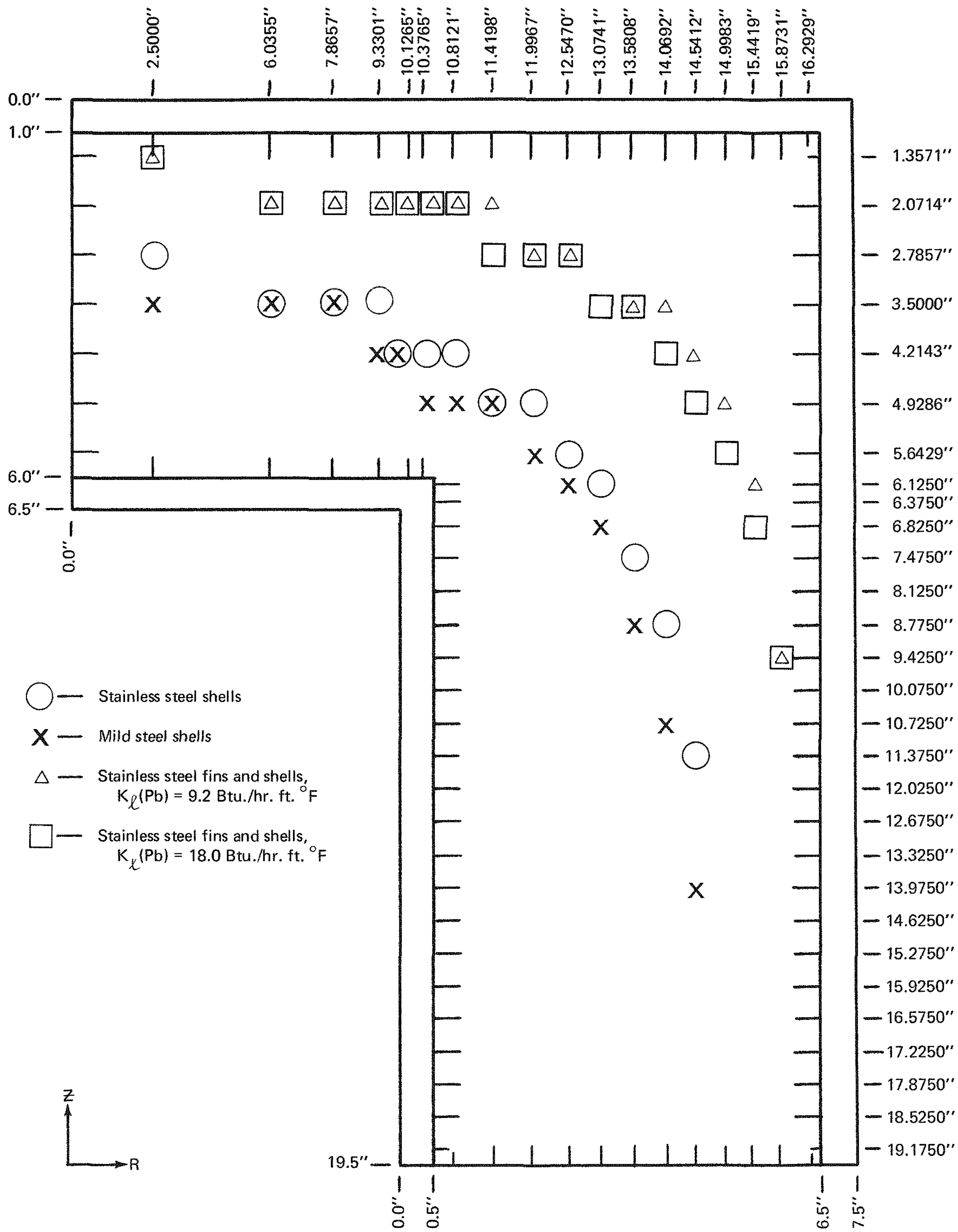

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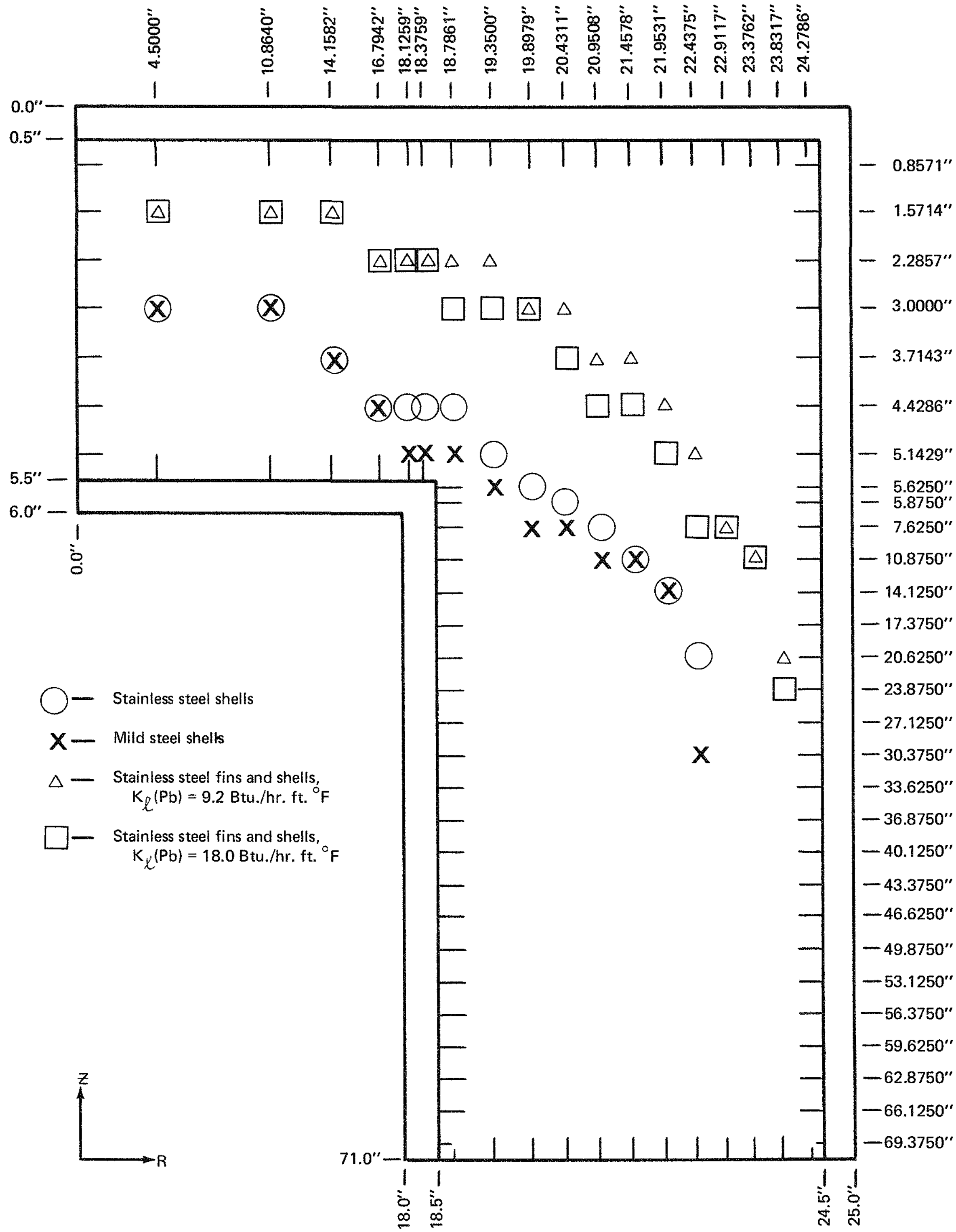

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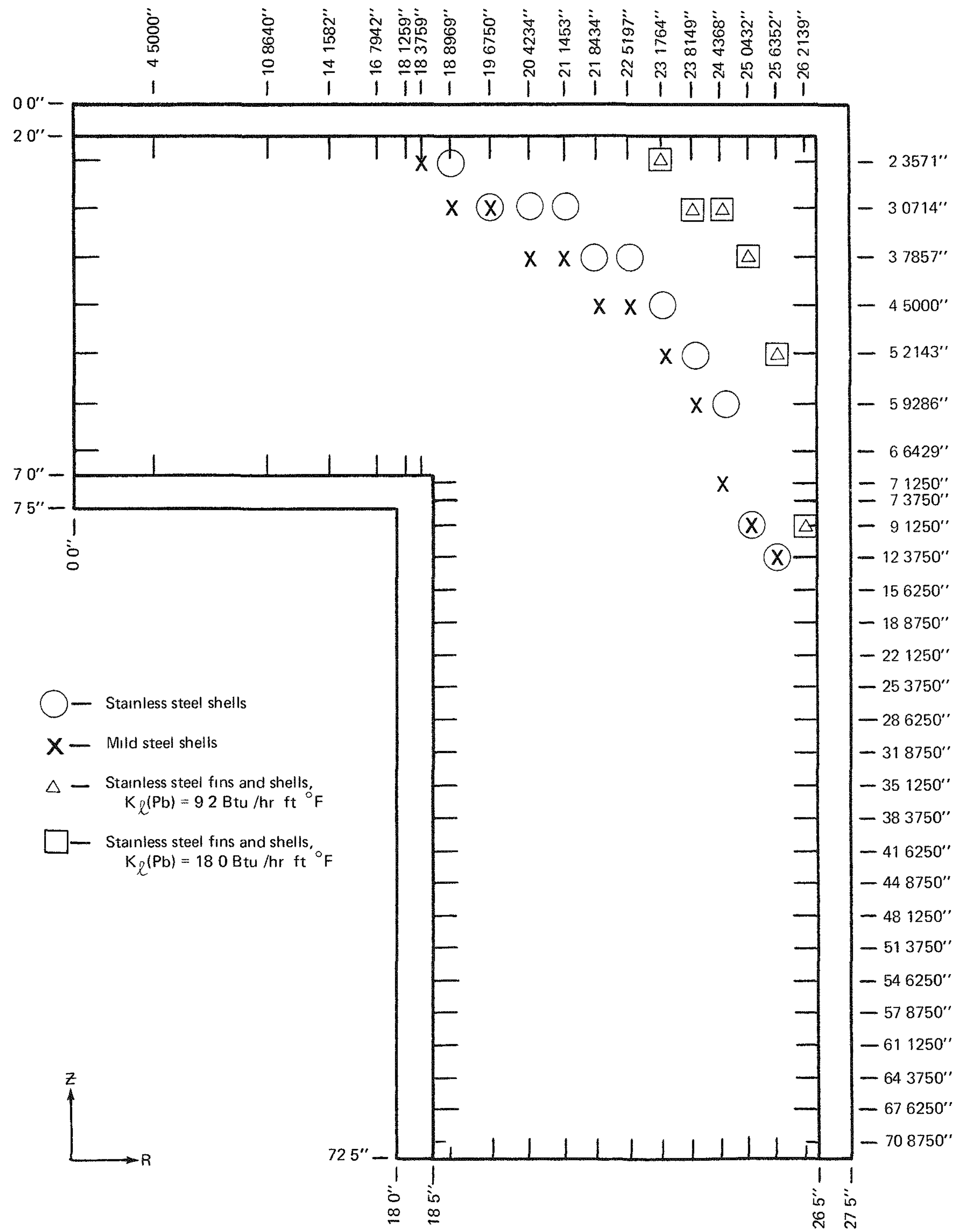


Figure 6. Melt Front Distributions.

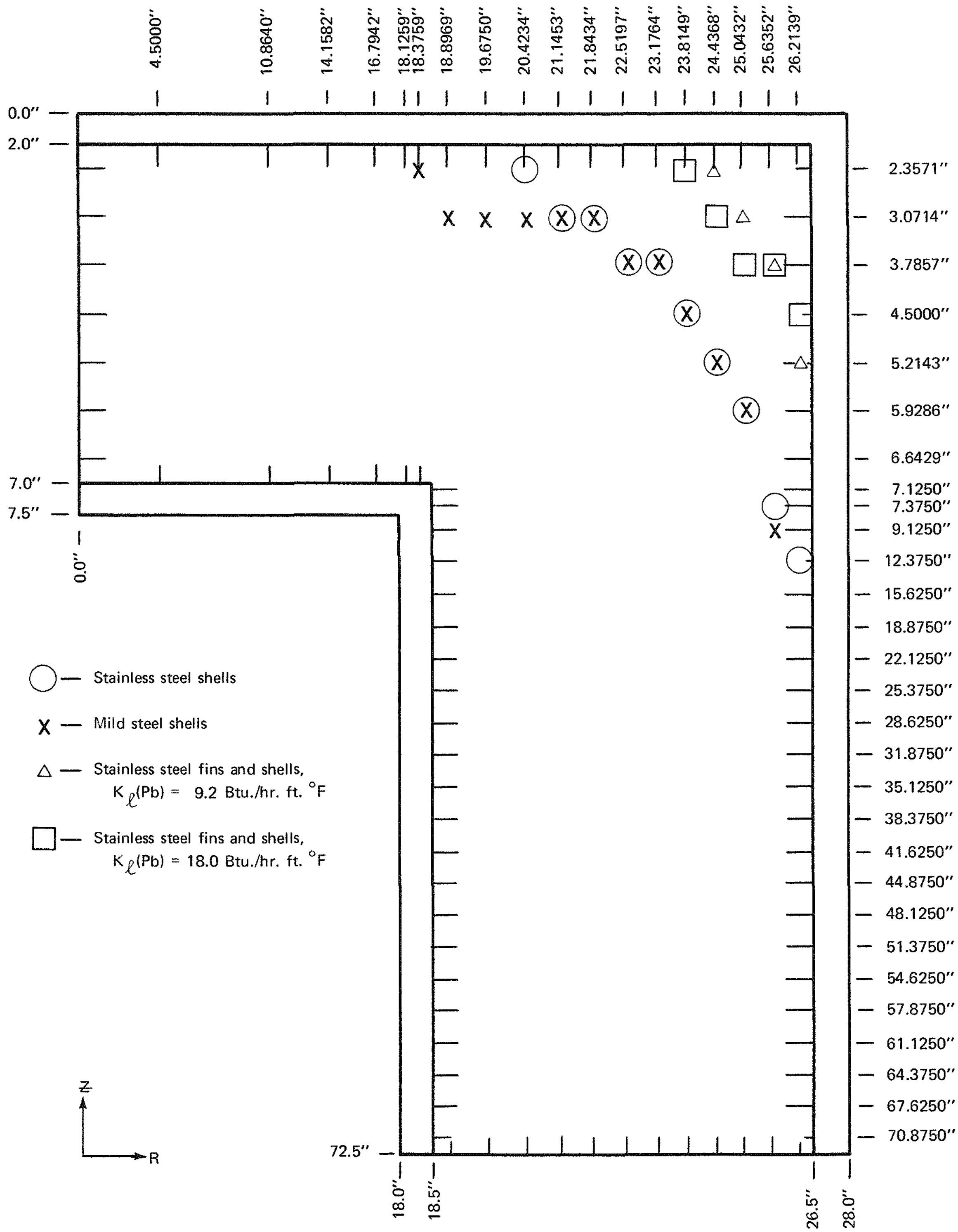


Figure 7. Melt Front Distributions.

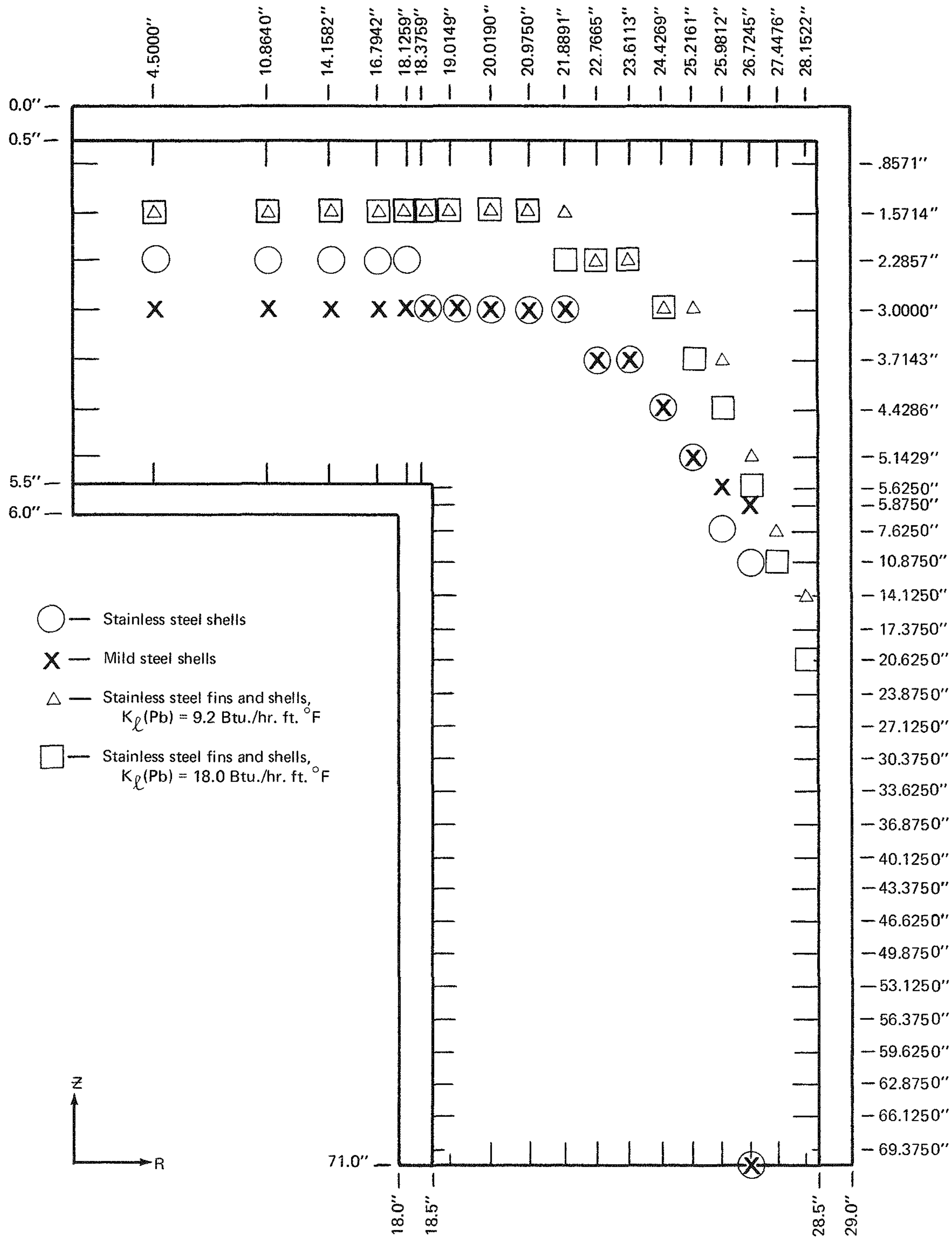


Figure 8. Melt Front Distributions.

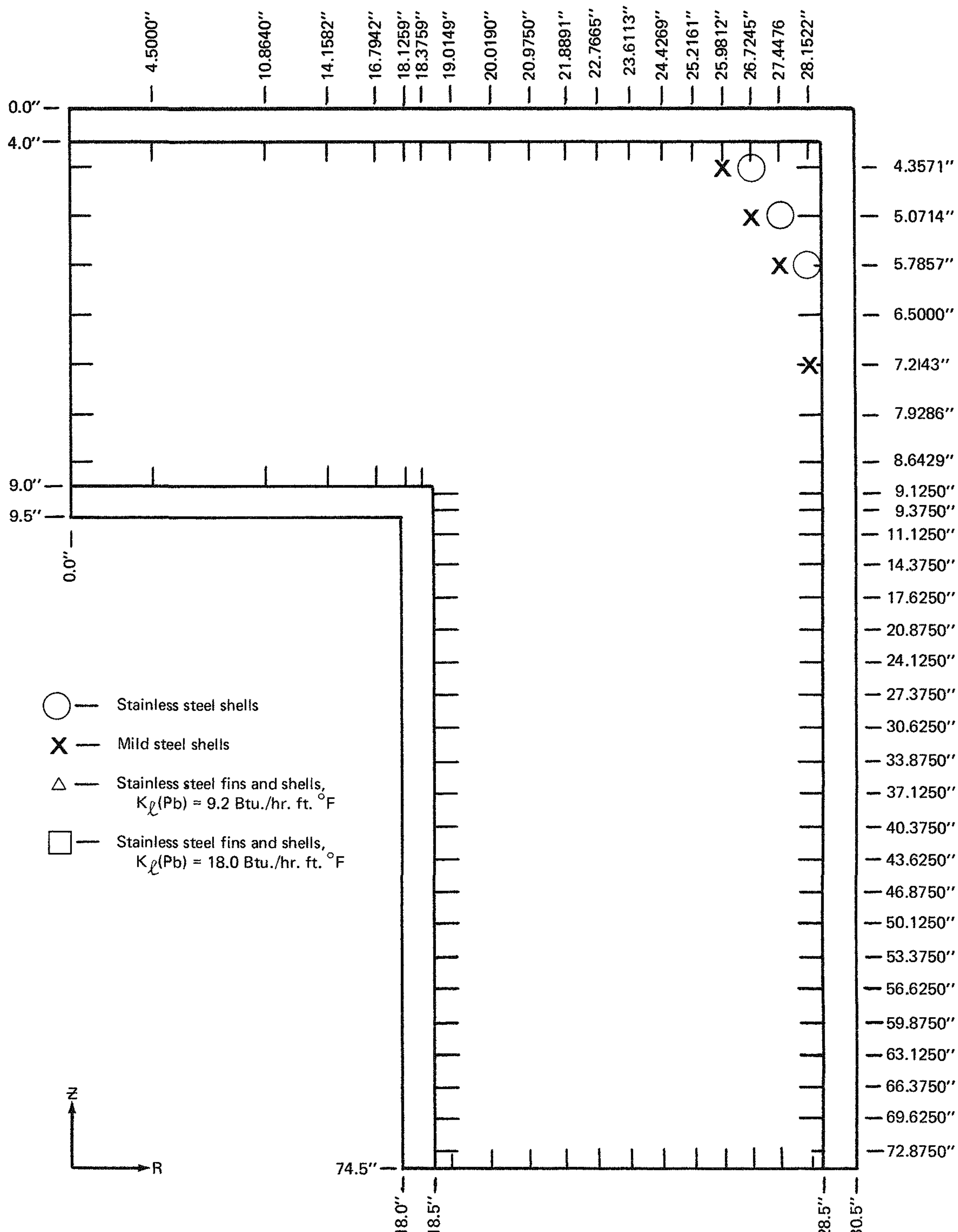


Figure 9. Melt Front Distributions.

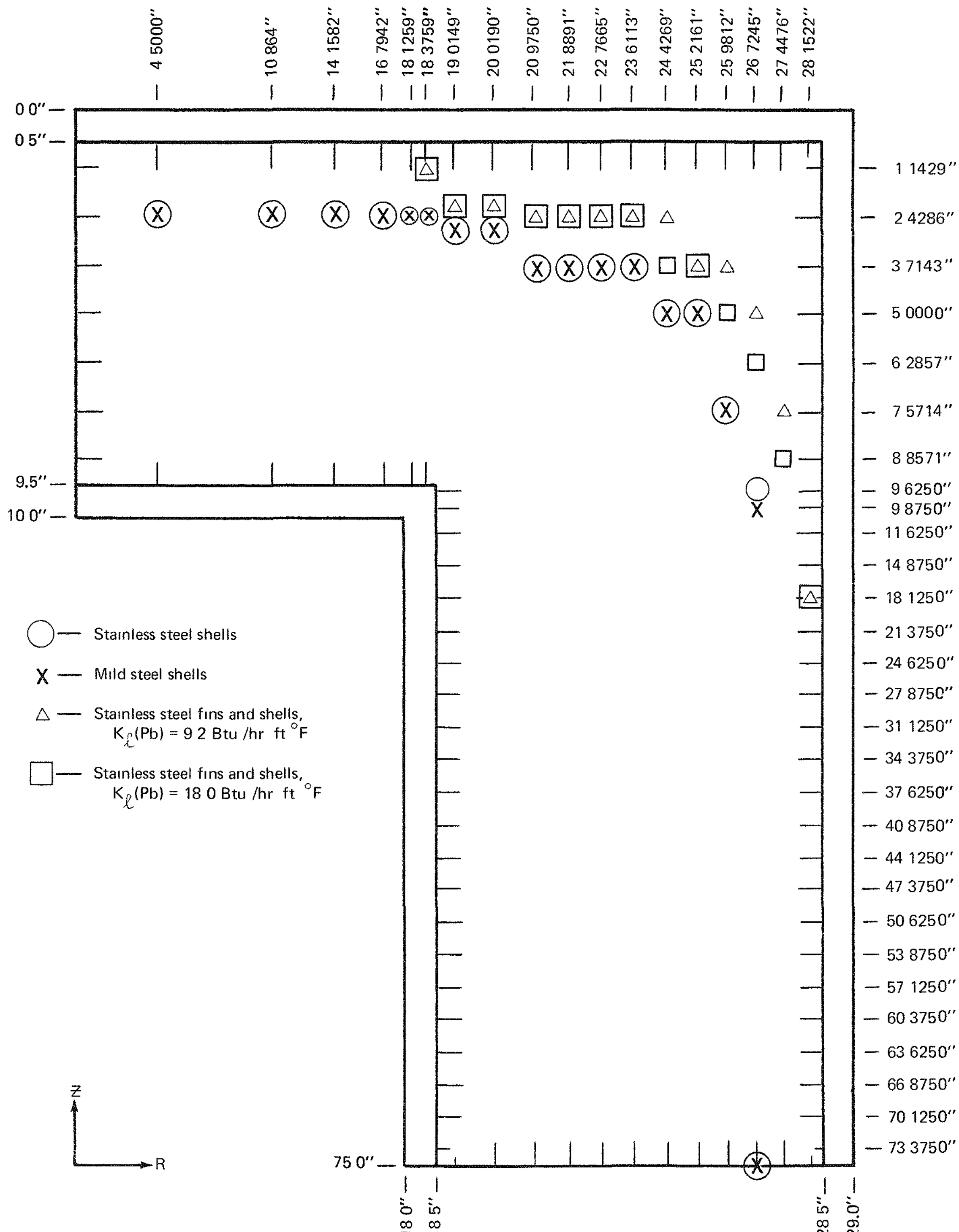


Figure 10. Melt Front Distributions.

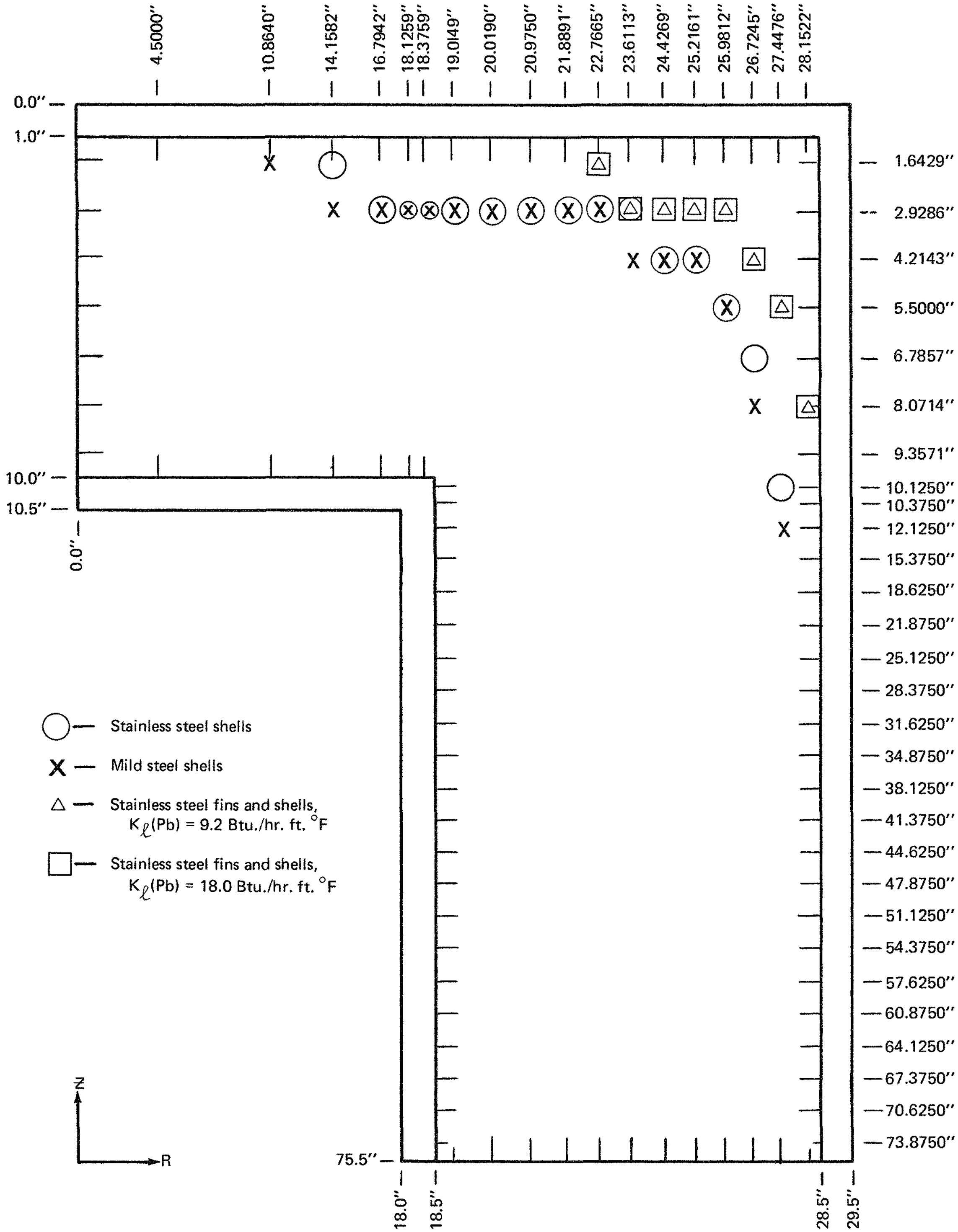


Figure 11. Melt Front Distributions.

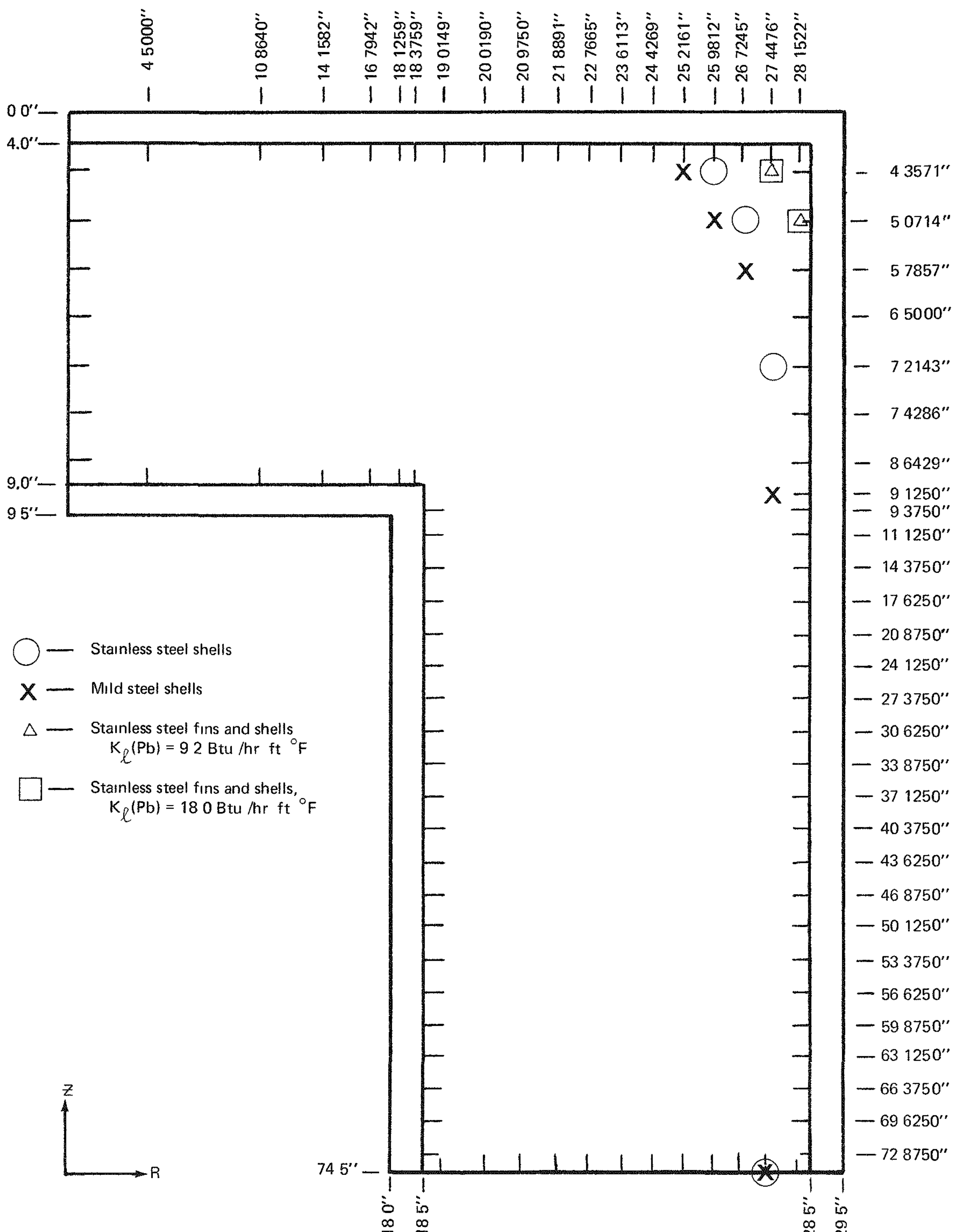


Figure 12. Melt Front Distributions.

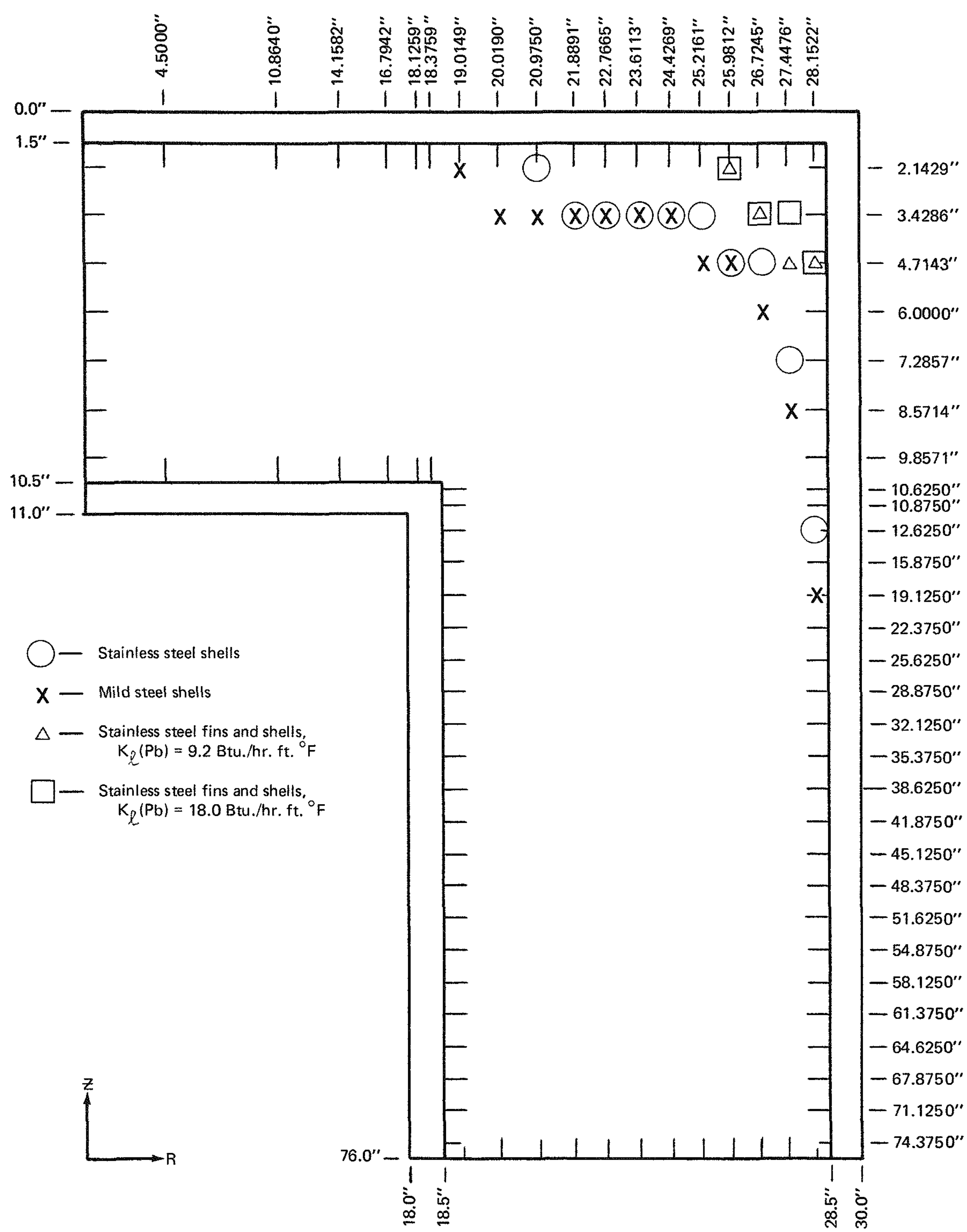


Figure 13. Melt Front Distributions.

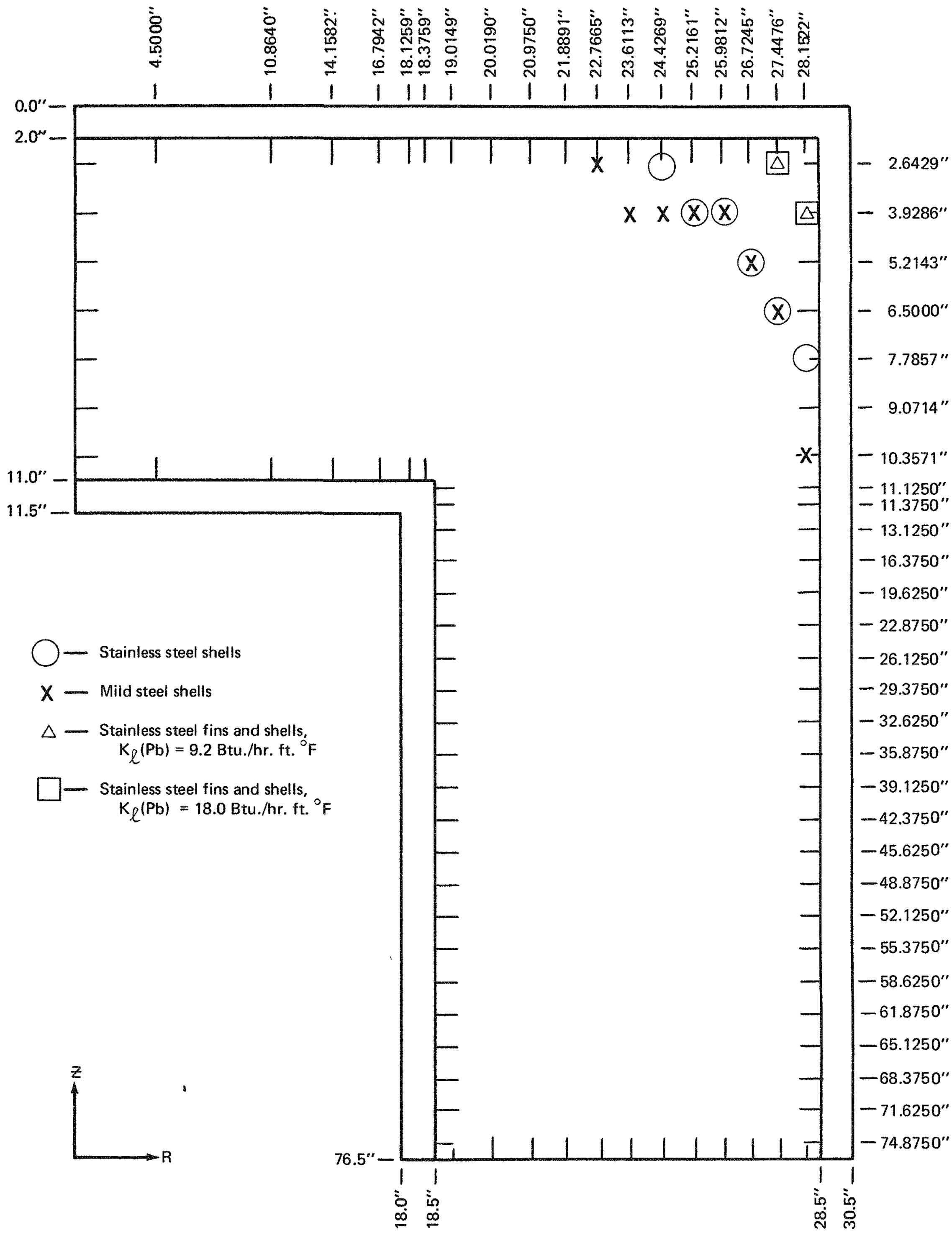


Figure 14. Melt Front Distributions.

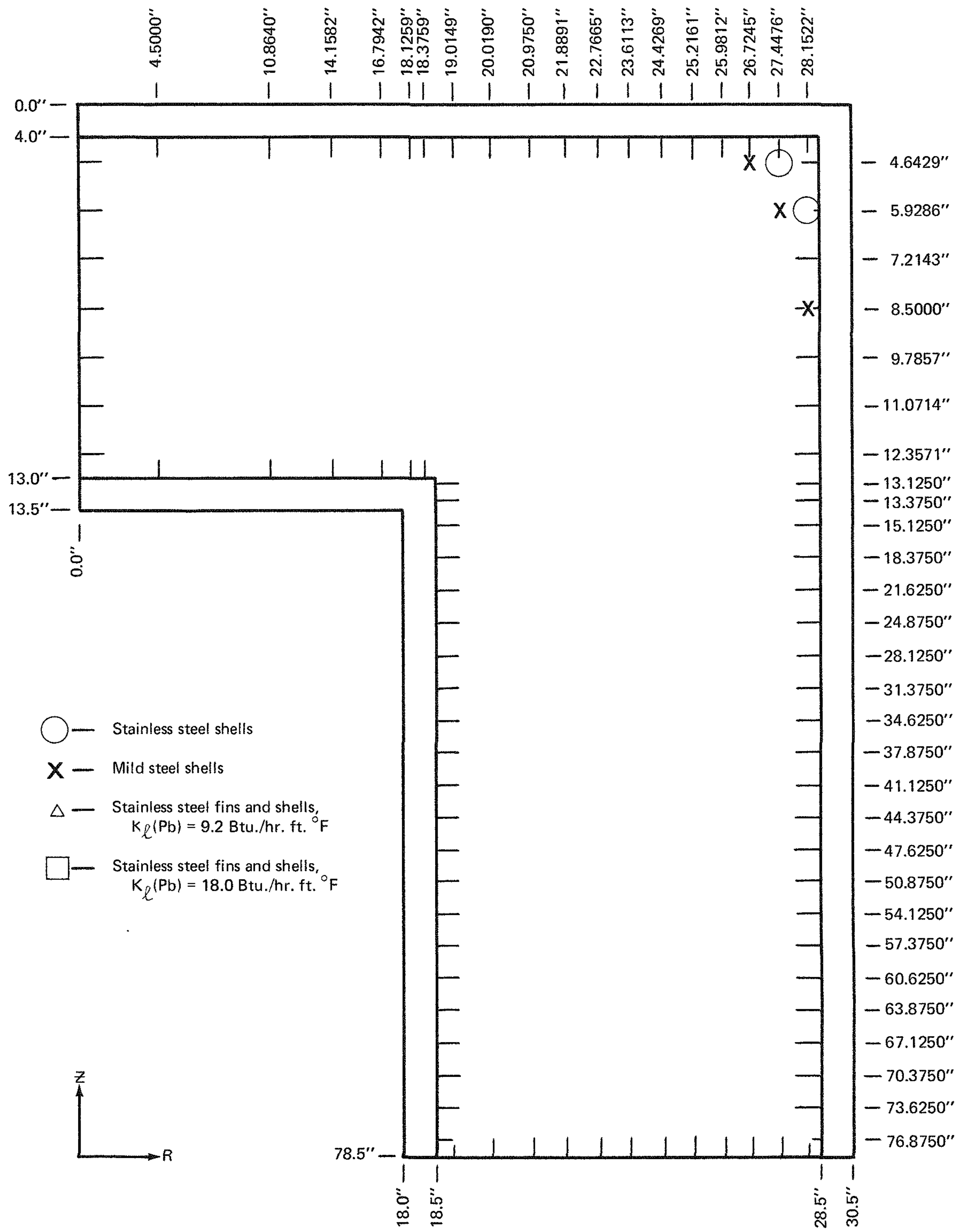


Figure 15. Melt Front Distributions.

EVALUATION OF PRODUCT FORM IN SAFETY OF PLUTONIUM TRANSPORTATION

L. M. Knights

ABSTRACT

This paper presents an evaluation of the safety aspects of shipping reactor fuel grade plutonium in various forms. The relative risks for shipment of metal, nitrate, and oxide are examined; and economic and operational effects are considered.

INTRODUCTION

The increasing use of nuclear power is resulting in a steady increase in the number of shipments of plutonium throughout the country. A proper concern of those responsible is that transportation is done safely. It is the purpose of this paper to present an evaluation of the safety aspects of shipping reactor fuel grade plutonium in various forms. The relative risks for shipment of metal, nitrate, and oxide are examined; and economic and operational effects are considered.

The conclusion of the evaluation is that plutonium as metal, nitrate, and oxide is being shipped under strict regulatory criteria which provide confidence that no material will be released to the environment during normal transport or if subjected to a hypothetical standard accident.

Accidents more severe than those for which packages are designed are considered so unlikely that no significant hazard is being imposed on the public. Support for this conclusion will be discussed under the following topical headings:

- Transport Regulations
- Current Shipping Practices and Related Considerations
- Economic Evaluation
- Safety Considerations
- Risk Comparisons

Transport Regulations

Regulations governing the packaging and shipping of radioactive materials have been developed by the Atomic Energy Commission and by the Department of Transportation (DOT). These regulations are, to a large extent, based on the Regulations for the Safe Transport of Radioactive Materials of the International Atomic Energy Agency. The United States regulations, therefore, represent an international consensus of good practice.

The underlying principle of the regulations is the evaluation of the response of a package and its contents to a standard accident and a judgment of the package safety based on this evaluation. Criteria which define the standard accident may be found in AEC Manual Chapter 0529 and in Title 10, Code of Federal Regulations Part 71. To assure that a package will meet the criteria, it is subjected to a 30-foot drop test, a puncture test involving a 40-inch drop onto a 6-inch diameter spike, a half-hour fire test at 1475° F (802° C) and immersion in water. No claim is made that the standard accident represents the most extreme transport accident to which a package might be exposed. However, the likelihood of more severe accidents is so low that the associated risk was considered acceptable in developing the regulations.

It should be noted that the validity of this approach to safety is dependent on the assumption that packages are properly prepared for shipment, a point which has received continually increasing administrative attention.

Current Shipping Practices and Related Considerations

Plutonium is shipped in various forms. The most common are oxide, nitrate, and metal. Typical containers in use, as well as administrative controls which have been found effective, are described. Some observations on related problems of storage and heat dissipation are also noted.

Almost all plutonium nitrate solution shipments utilize one of two similar containers which were developed by the Dow Chemical Company, Rocky Flats Plant, of the Atomic Energy Commission. These containers have capacities of 3 and 10 liters and are commonly referred to as the L-3 and L-10 containers. Extensive testing[1] has demonstrated compliance with applicable regulations and has resulted in the issuance of DOT special permits.

The L-3 container consists of a 3-liter polyethylene bottle enclosed in a plastic bag, placed in a sealed schedule 80 (0.375-inch wall) steel containment vessel which has a rupture strength of about 10,000 psi, with flange bolts that rupture at 4200 psi. The vessel used to be gasketed with a gas-filled, stainless steel O-ring which has been replaced with a viton or similar gasket. The containment vessel is surrounded by vermiculite packing in a 55-gallon drum and has provisions for venting.

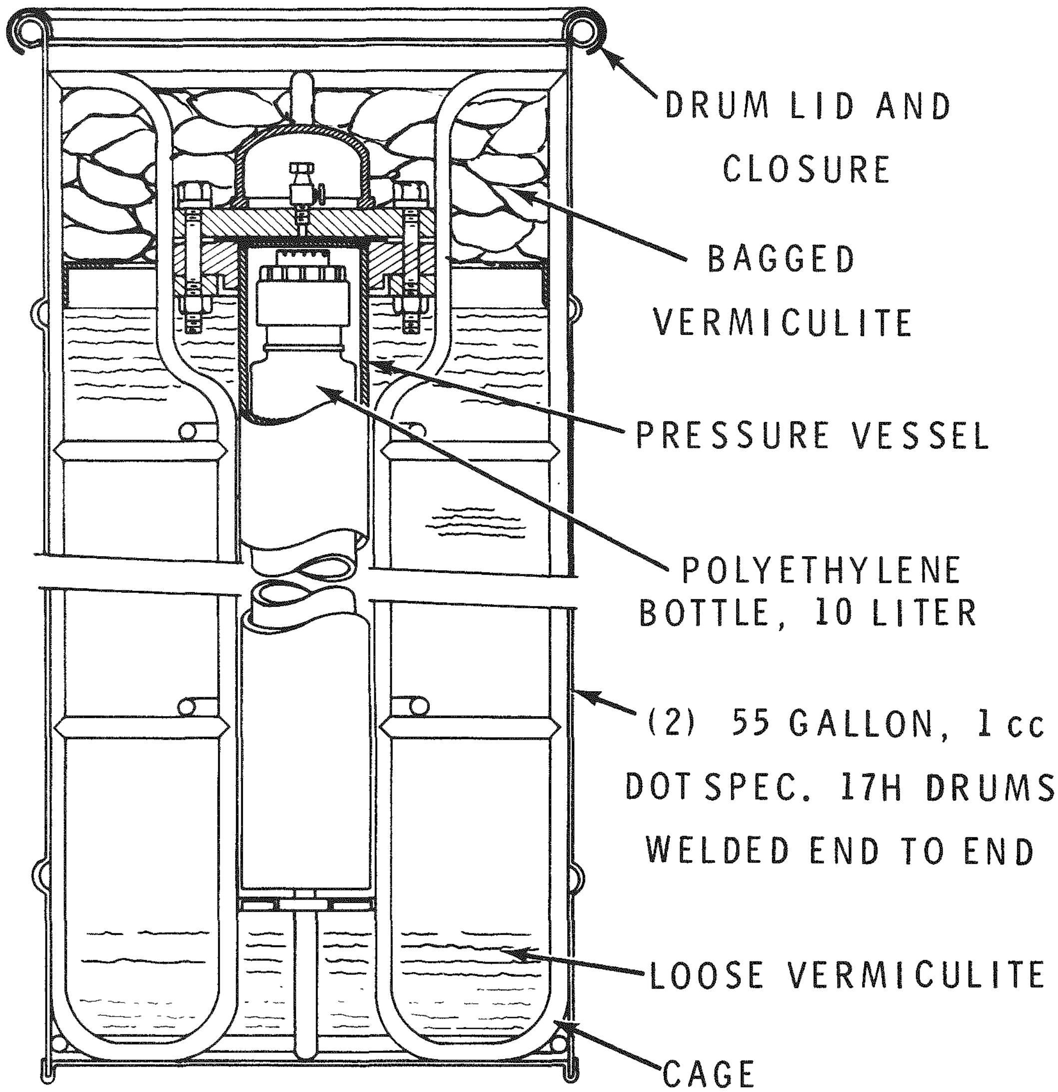
The L-10 container uses a 10-liter polyethylene bottle with similar packaging in a 110-gallon drum.

Plutonium nitrate, as usually shipped, has a concentration of about 200 grams plutonium/liter, so that the L-3 would contain about 600 grams and the L-10 about 2 kilograms of plutonium.

There are several containers approved for shipment of plutonium metal and oxide. A widely used container is the DOT Specification 6M, which consists of a schedule 40 (0.250-inch wall) steel pipe containment vessel.

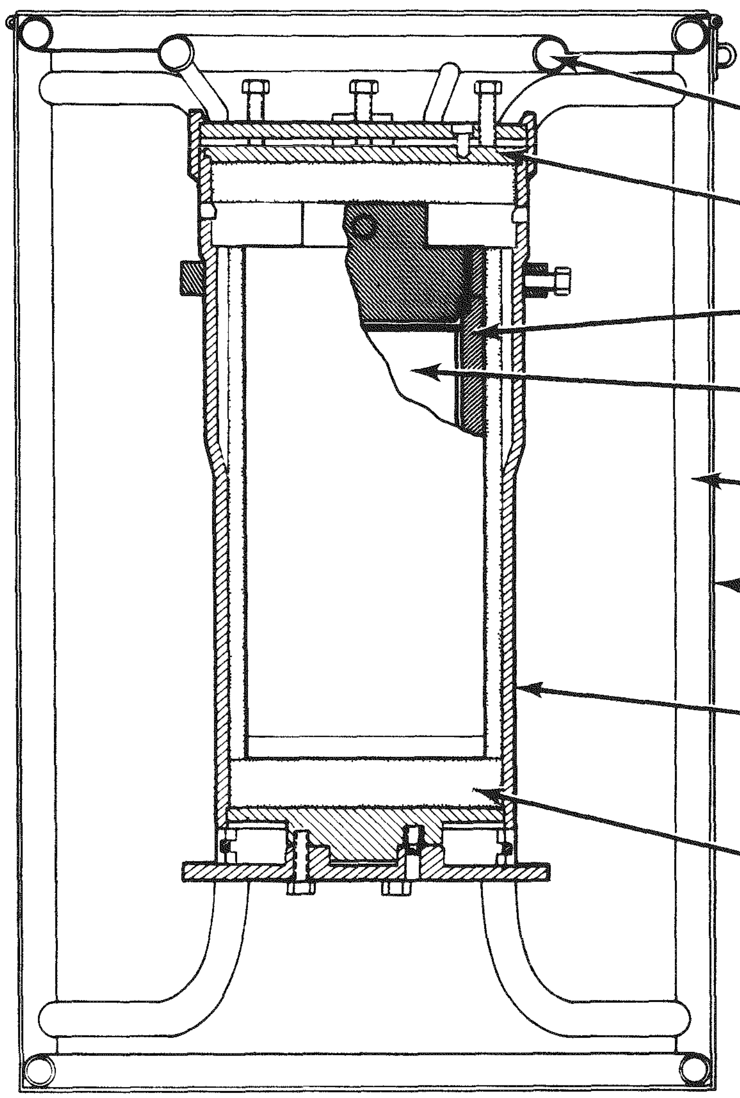
TYPE L-10 SHIPPING CONTAINER

(DOT - SP - 5061)



TYPE LLD-1 SHIPPING CONTAINER

(DOT - SP - 4960)



The vessel may vary between $4\frac{1}{4}$ inches to $5\frac{1}{4}$ inches inside diameter and 10 inches to 56 inches tall, and is placed in a steel drum with industrial cane fiberboard insulation and packing. The specified capacity is 4.5 kg of plutonium as metal or oxide, and the total package volume may be as small as 10 gallons or as large as 110 gallons. The test program which demonstrated the acceptability of this package was also performed by the Dow Chemical Company.[2]

Large quantities of plutonium metal have been and are being shipped in containers which are authorized under a DOT Special Permit Number 4960. These are LLD or KKD "birdcage" containers consisting of a welded tubular steel framework and a 1/4-inch thick steel containment vessel. Material (plutonium metal or oxide in #3 cans) is packaged in an additional schedule 120 (0.500-inch wall) inner steel thimble. The test program which demonstrated the suitability of this container was performed by the United Kingdom Atomic Energy Authority and by the Dow Chemical Company. The container passed the maximum foreseeable transport accident conditions in successive order without a significant increase in criticality hazard, without external dispersion of radioactive material, and without loss of radiation shielding. These conditions are listed below:

1. Water spray simulating driving rain, followed by
2. Vibration, 5 to 100 cps, horizontal and vertical, in several planes simulating transportation, followed by
3. Impact of 30-foot free drop onto the horizontal 12-inch flange of a heavy steel beam with major axis of container horizontal, followed by
4. Water immersion under 3 feet head for 24 hours, followed by
5. Impact similar to test 3 above, except with major axis of container vertical, followed by
6. Fire and quench consisting of 30-minute exposure in heat-treating furnace at 800° C (1472° F), followed by a 20-minute quench in water 3 feet deep over the uppermost part of the container.

As noted earlier, packages must be prepared properly for shipment. The loading for shipment must be done under very carefully controlled conditions. For example, procedures should receive independent technical reviews and managerial approvals. Each loading step should be compared against a check list and certified, and audits made to further assure compliance. The seal on the gasket for nitrate shipments should be confirmed by a pressure test. Metal should be canned in a dry, inert atmosphere for storage and shipment. Through the use of such care, no release of material has been encountered in any of the shipments from Hanford.

There are other considerations which bear on the evaluation of product form when considering the safety aspects of shipping plutonium. For example, receiving and unpackaging of metal or oxide is considered to be less troublesome than for nitrate. The nitrate evolves gases as a result of radiolytic disassociation of the liquid.[3] To avoid a pressure build-up in the inner polyethylene container, the gas is vented into the plastic bag. This has been known to cause occasional contamination to the interior of the steel containment vessel if the plastic bag has broken.

Long-term storage of plutonium nitrate is less convenient than storage of the oxide or metal because of the bulk and because the gas evolved must be released periodically. The problems associated with gas evolution will be aggravated for plutonium from liquid metal fast breeder reactor (LMFBR) operation, for example, due to the higher specific alpha activity of that plutonium. It has been considered desirable by some to transfer nitrates to new polyethylene containers after a year in storage, and not to use bottles for DOT shipments which have been in storage service for longer than 30 days. This extra precaution is proposed to guard against possible plastic stress cracking and failure caused by pressure.

Both metal and oxide are canned in dry atmospheres (< 0° F dew point). It should be noted that packages of low-fired oxide which contain excessive quantities of volatile material may also pressurize. Further, it has been observed that cans of metal in storage can rupture after prolonged storage where the seal has not been tight, allowing oxidation to take place. Recent tests[4] have shown that as isotopic levels increase, the heat given off by metal cannot be dissipated adequately from the present shipping container because of the insulation surrounding the thimble. From this, one might conclude that the amount of plutonium per container would have to be limited and/or some insulation removed.

It is recognized that the shipment of plutonium nitrate has been compared unfavorably with oxide and metal even though all have been shipped in a safe and prudent manner for a number of years. In spite of some disadvantages associated with the shipment and/or storage of nitrate solution, the process advantages have caused this to remain a standard form for shipment. The nitrate is chemically flexible and is the most convenient starting point for many processes.

Economic Evaluation

Plutonium packaging and transportation costs are estimated to be about $50 per kilogram less for either metal or oxide than for nitrate. This differential will tend to encourage shipment as the oxide. However, if the oxide form is not usable by the receiver, the cost of converting from oxide to nitrate for processing back to oxide will offset this gain. Several cost studies have been attempted, with indications that these conversion costs would exceed the cost savings by at least an order of magnitude.

The nuclear fuel recycle industry is growing steadily. Several years ago, the major fuel forms considered for LMFBR were oxide, cermet, and carbide. At the present time, only oxides are being actively pursued for light water reactors (LWR) and the LMFBR. Economy suggests that future trends will either reduce the "oxides of interest" to a relatively small range and/or permit the specification of an intermediate oxide form which may facilitate direct conversion of plutonium nitrate to an acceptable solid feed material prior to shipping to the fuel fabricator. Hence, it is probable that standard plutonium forms, other than nitrate, will evolve within the private fuel sector of the nuclear industry.

The prohibition of shipments of a specific form, such as the aqueous nitrate solution, would impose the requirement for conversion to solid, per se, which could diminish the utility or marketability of the material leaving the reprocessing plant.

Safety Considerations

Consideration of risk from accidents related to transportation may be facilitated by grouping the accidents into four categories.

The first is the transport accident which is no more severe than the standard accident. The few accidents which have occurred in public transport of radioactive material have been of this class and have presented no significant hazard. Reportable accidents of this type have averaged about one in 10,000 shipments.[5]

The second is the improbable transport accident which is so severe as to invalidate the accepted approach to package safety. Such accidents are thought to have a national frequency of about one in two years for all commodities in transport.

A third type accident is the large truck-terminal fire. Here environments significantly more extreme than the standard accident might be encountered, particularly in respect to the duration of a fire.

A fourth accident type of concern is related to the receipt of a package by the consignee. While this would not involve the general public, it may present a significant risk to the receiver.

Accidents or incidents related to the receipt, storage, and unpackaging of material will be of limited consequence, but do introduce the possibility of contamination of personnel and equipment. This risk must be controlled by the use of appropriate procedures for packaging, unpackaging, and storage of material, and is in the purview of the shipper and receiver.

The probability of release or dispersal of material will be insignificant for accidents not exceeding the "standard" type for any approved package regardless of the form of the contents. Provision of this degree of safety is the function of current regulation.

The second and third types of accident are not amenable to explicit evaluation in that there is no upper bound to the damage a package might receive. A great threat to the ability of a package to retain its contents would be expected to arise from prolonged exposure to a high temperature environment. As an example, the viton-A gaskets of the containment vessels of the nitrate shipping containers now in use have been found[1] to fail at an internal pressure of about 1400 psi, corresponding to a saturated steam temperature of about 572° F (300° C). This should be compared to the observed 50° F (10° C) rise in temperature encountered by a nitrate containment vessel during exposure to a 45-minute furnace test at 1475° F (802° C). It follows that dispersal of material from these containers could occur as a result of degradation of the insulation followed by extended exposure to high temperature. Should such an event occur, the form of the package contents would have a significant influence. The generation of high steam pressure in a package containing plutonium nitrate would lead to failure of the containment vessel gasket and dispersal of some of the contents, probably as an oxide having small particle size. (Not all would be dispersed, since the solution would concentrate, go through a mastic stage, and then convert to the oxide.)[4] Packages containing suitable fired oxide or metal would not be expected to generate high internal pressures, and therefore dispersal of plutonium is less likely.

Accidents in which a package suffers extreme physical damage would be expected to result in dispersal of the package contents regardless of form. As an example, if a package were crushed, as might occur in a truck-train collision, either oxide or nitrate could be scattered and metal would probably suffer rapid oxidation and subsequent dispersal.

An attempt was made to evaluate the probability of occurrence of accidents which would result in the release of material from properly designed packages. A basic difficulty was that compilations of transport accident experience are designed to provide information on fatalities per vehicle or passenger mile, or dollar loss per vehicle or ton mile for cargo.

In that no other industry has ever designed packages to the kind of accident criteria applied by the nuclear industry, there has not been a requirement for data in terms of the severity of impact, acceleration force imposed on packages, or temperature or duration of fire.

From Motor Carrier Accident Frequency records, coupled with some basic assumptions and approximations, an attempt was made to compile information pertinent to radioactive material transport safety, with the following results:

1. There is one extreme accident in two years for all commodities in transport. (This would be an accident of such severity as to lead to the dispersal of plutonium if present.)
2. There are 800,000 semitrailers and trucks in national service.
3. There is an average plutonium consignment of 10 kg.
4. Current nonweapons plutonium shipments approximate 4 metric tons/year. This implies a total of about 400 shipments of plutonium a year.

The average truck haul in the western United States is about 1500 miles, or two days. If one assumes a utilization factor of 1/3, then the 800,000 trucks and trailers would average one haul every six days or 60 hauls a year. There is, then 48 million truck hauls a year, 96 million hauls in two years, or about 100 million hauls between extreme accidents.

At an annual rate of 400 plutonium shipments, it should be expected that plutonium would be involved in an extreme accident once in 250 thousand years.

It is estimated that there are in this country about 10,000 large truck terminals, where one might encounter an unusual accumulation of combustible materials, and that a significant truck-terminal fire occurs about once every 20 years. Then any one terminal has an expectation of one major fire in 200,000 years. If an average plutonium shipment spends two days in terminal, using our estimated 400 shipments a year, one might expect a terminal fire involving a plutonium shipment about every 100,000 years.

While these results may be varied by using different but still reasonable assumptions, one will conclude that shipment of plutonium in any form under present AEC criteria is an eminently acceptable risk.

Risk Comparisons

Representatives of the AEC and contractor personnel recently attempted a comparison of the relative risk associated with the shipment of plutonium as nitrate, oxide, or metal. The first and major point recognized was the very high level of safety associated with any shipment which was in compliance with applicable regulations. While differences existed in the degree of risk associated with the various forms of material, the risk of shipping plutonium in any of these forms was considered so small as to be negligible.

The oxide is the most stable chemical form of plutonium which is frequently considered for shipment. The physical form of the oxide is an additional variable. A report from ORNL[4] has shown that the PuO_2 high-fired microsphere represents the safest form known. The desirable safety characteristics of a PuO_2 microsphere include: (1) chemical inertness, (2) low leachability, (3) low dusting, (4) high specific particle strength, and (5) good stability to thermal shocking. Although microspheres have been prepared commercially in fuel fabrication operations, the technology is new, little operating experience has been accumulated, and reprocessing costs are high.

Shipment of plutonium metal has been a subject of concern to some because of the possibility of the formation of a low melting point, plutonium-iron eutectic during a fire. Indications are that approximately 1/4-inch thickness of iron will provide containment, and recent tests have demonstrated that the eutectic does not form in the presence of oxygen.

Shipment of plutonium nitrate presents a somewhat higher possibility of the material being dispersed, but only if a package is exposed to a higher temperature for a longer time than those corresponding to the standard accident. Such an occurrence is recognized as being of low probability for the quantities of plutonium being shipped.

It may be appropriate to note that for the entire industry, one may expect two or three orders of magnitude increase in plutonium production over the next several decades, largely from the power reactor fuel cycle, with important changes in isotopic composition. With such an increase in shipment frequency and increased radiolytic gas generation rates for solutions, if the material form is largely nitrate, the aggregate risk may no longer be negligible. It does appear, however, that the level of nitrate shipments will decrease and oxide shipments will increase.[7] Calculations indicate that in the future the expectation of an accident in which plutonium would be released might approach one in 100 years. Such an expectation would be completely acceptable to most industries, but under the present climate might not be acceptable for the nuclear industry.

CONCLUSIONS

As noted earlier, this study included consideration of existing strict transport regulations and the requirement for high integrity containers, economic considerations, relative risks, and safety considerations. It was concluded that plutonium is being shipped under regulatory criteria which provide confidence that no material will be released to the environment during normal transport or under the hypothetical accident conditions of 10CFR71. Under conditions of an accident more severe than the standard accident, the probability and consequences of material release are postulated to be somewhat greater for nitrate. However, the excellent safety record in the transport of plutonium does not provide confirmation based on experience.

There appears to be an inherent convenience and economy of shipping plutonium in forms other than nitrate. For example, the unloading and storage problems of the receiver are slightly more complex for nitrate than for oxide or metal. While shipping costs favor the oxide and metal, reprocessing costs presently negate this advantage.

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TITLE: THE EFFECT OF PLUTONIUM NITRATE SHIPPING ON THE REACTOR FUEL FABRICATOR

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ABSTRACT

The fuel fabricator should be able to maintain the option of receiving plutonium in the form of nitrate or oxide. Restrictions on shipping either form will impose restrictions on fuel fabrication. Receiving plutonium as nitrate gives the fuel fabricator more flexibility and better process and quality control. For safety considerations, there is no advantage of either oxide or nitrate using present shipping criteria, i.e., each has been shown to be safe.

INTRODUCTION

Recycle plutonium will soon become a significant factor in the reactor fuel cycle, this will mean an increase in the transportation of plutonium from the reprocessors to fuel fabricators. The amount of recycle plutonium will increase from 1 MT/yr. in 1973 to 30 MT/yr. in 1983. This will result in larger amounts of plutonium being transported, and this has caused some concern in the government and in industry regarding the safety of shipping this material.

In order to capitalize on the potential value of recycle plutonium it will have to be economically recycled, which means large, efficient fabrication plants and safe and economical transportation methods. Decisions made now on transportaion will have a significant effect on the overall cycle.

DISCUSSION

The reactor fuel fabricator should have the option of receiving plutonium feed stock as nitrate or oxide. Limiting the fabricator to only one form or the other would force him to become dependent upon a given reprocessor, or an intermediate processor. Further limits, such as requiring the plutonium to be converted to microspheres, would require additional head end processes in the fuel fabrication cycle.

Having the option of receiving material in either form would give the fabricator more flexibility in process selection and plant design. By having the flexibility the result would be a more reliable reactor fuel. A fully-integrated manufacturing plant including conversion, pellet and rod fabrication, scrap recovery and waste disposal would result in better process and quality control over the entire fabrication cycle. The fabricator could receiving oxide or nitrate and select any conversion method he desires depending upon his experience and requirements.

A fully-integrated plant would also mean better cost control and material accountability during the fabrication cycle. Receiving plutonium as microspheres would probably require dissolution and reconversion to oxide. Dissolution of this material is difficult, thus introducing more costs and accountability uncertainties.

There is no significant safety advantage in shipping nitrate or oxide under present criteria. In recent years hundreds of Kgs. of plutonium have been shipped as nitrate throughout the country without any incident which would impair public safety. Westinghouse would welcome any improvement in present shipping containers including larger volumes per container.

A SIMPLE SHIPPING SYSTEM
FOR POWER GRADE PLUTONIUM OXIDE

R. E. Giebel
R. G. Leebl

ABSTRACT

A primary experimental shipping container has been developed which utilizes magnesium oxide sand for heat transfer purposes. The experimental container has been used to ship plutonium oxide with a specific power output of ~4 watts per kilogram. The primary container was designed to fit the 6M shipping system which has D.O.T. approval. This container was not designed to serve for storage purposes and is recommended for shipping only.

The plutonium oxide is loaded into the primary container which is a nominal 1-1/2 inch diameter by 6 inch long stainless steel pipe with a wall thickness of 0.145 inch. The pipe is fitted with a threaded cap and a Teflon® gasket for sealing purposes. The loaded pipe container is removed from the glovebox line in a polyvinyl chloride (PVC) bag which serves as an alpha contamination barrier. The bagged pipe is placed into a No. 901 mild steel can. The unoccupied annular space in the can is filled with magnesium oxide sand and the can is sealed with an automatic sealer. The sand-filled, sealed 901 can is subsequently placed in the 6M shipping container for transport off site. This shipping arrangement will accommodate about 800 grams of plutonium oxide per container.

Construction, utilization, and comparison with other shipping systems employed by Rocky Flats are discussed. The formulation of design criteria based upon heat transfer calculations and experimental temperature measurements are also reviewed.

INTRODUCTION

Plutonium oxide (PuO_2) of high specific power output is occassionally shipped from Dow, Rocky Flats. Plutonium in the latest shipment had a ^{240}Pu content about three times higher, and a ^{241}Pu content about 8 times higher, than Rocky Flats stream plutonium (^{240}Pu = 15% vs 5.7%, ^{241}Pu = 3% vs 0.4% by weight). Americium-241 content was about one percent. Power output as heat from this type of PuO_2 is about 4 watts per kilogram.

After storage for about three months in a pint metal can, 2 Kg of this oxide significantly degrades a polyvinyl chloride (PVC) cutout bag used as an alpha contamination barrier (Figure 1). Tne plastic appears charred. This effect is attributed to a combination of heat and radiation.

For offsite shipment, a packaging system is required which insures integrity of the alpha containment structure (the PVC cutout bag). The temperature to which the PVC is subjected must be less than 200°F. To accomplish this, the quantity of PuO_2 within a primary container was reduced from 2 Kg and a heat transfer medium (magnesium oxide sand) was used to dissipate the heat by conduction.

This report describes the development work performed to verify that the container system devised would dissipate the heat, reduce degradation of the PVC, and prevent subsequent release of radioactive contamination. Additional information was sought which could be applied to future shipments of high power output plutonium.

Figure 1. Charred Polyvinyl Chloride Cutout Bag with Containers

EXPERIMENTAL

Schedule 40 stainless steel pipe (1-1/2") was chosen as the container for plutonium oxide. Six inch lengths of the pipe are welded closed across the bottom and threaded at the top. A pipe cap with a Teflon gasket seals the container (Figure 2). This low cost, primary container holds about 800 grams of PuO_2.

Various power output levels (from 1.58 to 5.35 watts) were attained by filling a modified pipe container (Figure 3) with Rocky Flats stream plutonium oxide (2.08 watts per kg) and mixing in varying progressively larger quantities of americium-241 oxide (92.1 watts per kg) without changing the plutonium base. Seven hundred sixty grams of plutonium oxide powder from burned metal chips were used as the base material. Heat output (1.58 watts) was calculated from: 1) X-ray fluorescence analysis for plutonium content, 2) mass spectroscopy analysis for plutonium isotopic content, and 3) radiometric analysis for ^{241}Am content. (See Appendix for calculation). Power output of the $^{241}AmO_2$ was determined by calorimetric measurement on a weighed quantity of the material.

The filled primary container was enclosed in a PVC bag, the primary alpha containment structure. A heat transfer medium was considered necessary to remove (conduct) the heat generated and prevent excessive heat exposure to the PVC. Magnesium oxide sand was selected as the heat transfer medium because of its thermal conductivity ($k = 0.392$ Btu/ft-hr-°F), low cost, and desirable properties (non burning, stable, high melting point). Sand was poured into the bottom of a #901 mild steel can, the PVC covered primary pipe container was inserted into the can and additional sand was added to completely surround the container with about

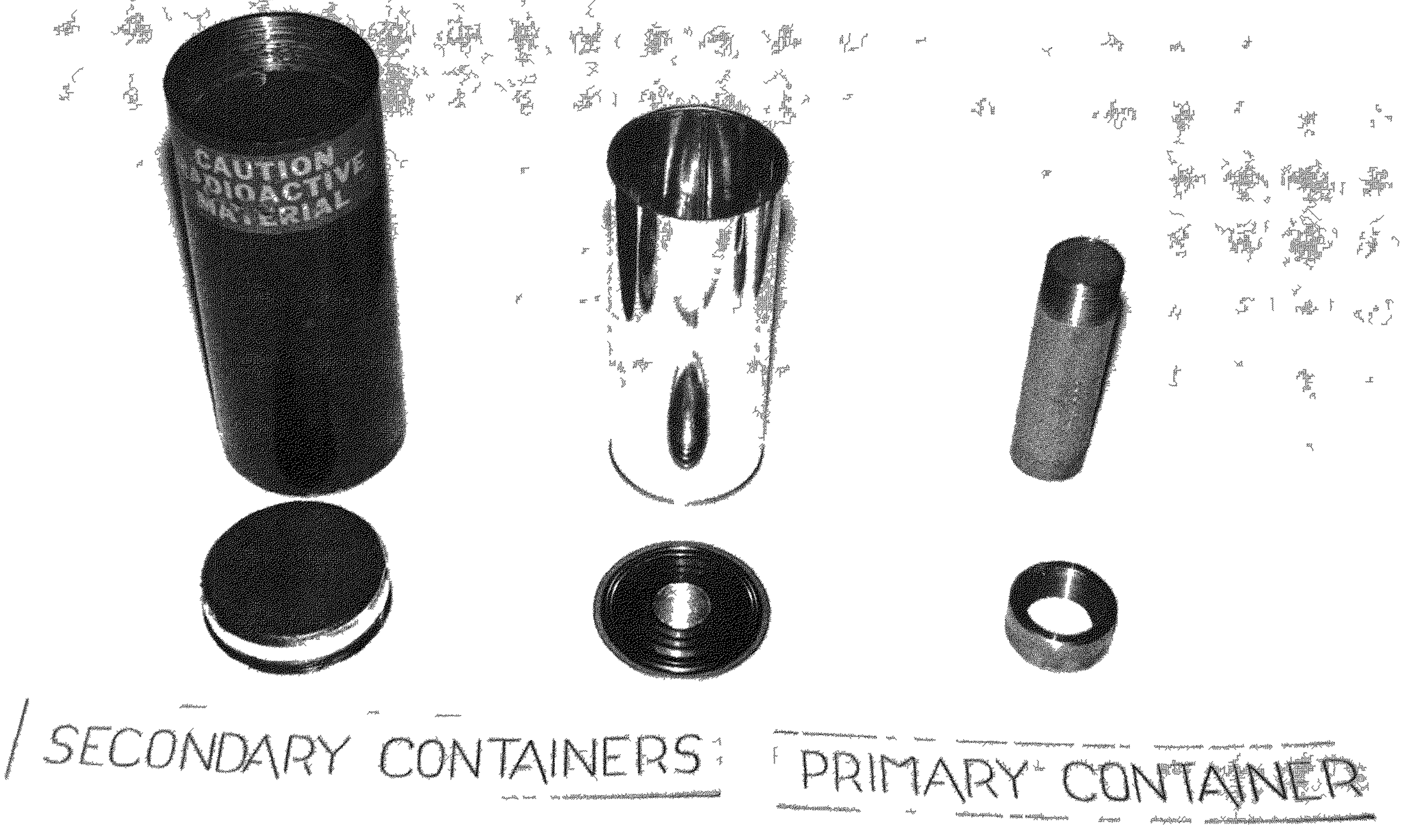

FIGURE 2. Container System for High Specific Power Plutonium Oxide

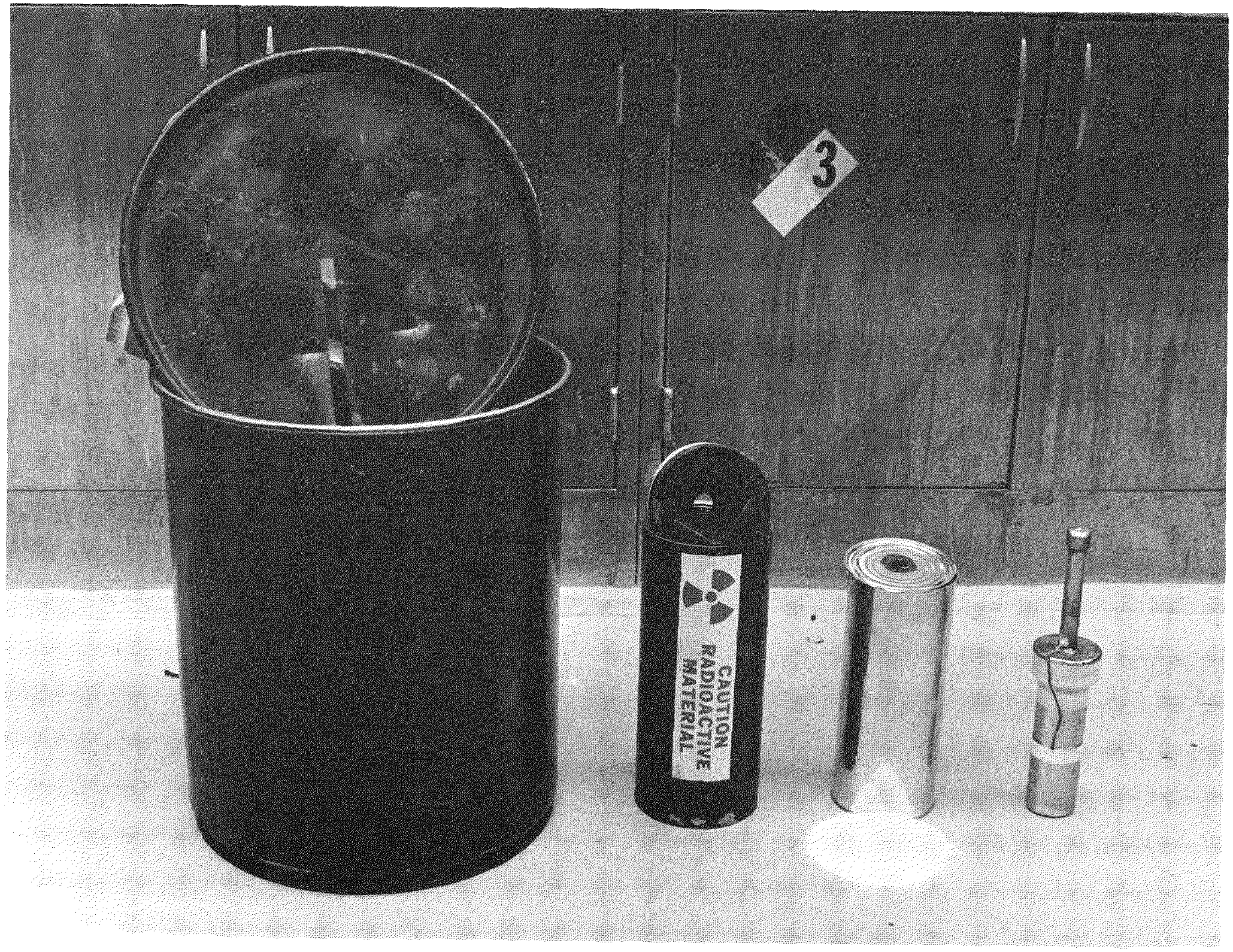

FIGURE 3. 6M Shipping System Modified for Temperature Measurement Experiment

1 inch of sand (Figure 4). For these experiments, the lid was secured with Duxseal. For shipment off site, the can was sealed. The #901 can fits snugly into the pipe container of the 6M shipping system (Figure 2 and 3), which has Department of Transportation approval[1].

Temperature measurements were taken at various locations within this shipping system to determine equilibrium temperatures. Copper-constantan thermocouples were located throughout the system as follows: (Figure 5)

1. In a well which extended into the center of the oxide.
2. Against the outside of the primary container.
3. Outside the 901 can.
4. Outside the 6M pipe container (inside the Celotex insulation).
5. Outside the 6M can (ambient).

A Honeywell Model 153 circular chart recorder, range 0-150°F, was used to record ambient temperatures. To record the temperatures within the shipping container system, a Leeds & Northrup multipoint strip chart temperature recorder was used.*

Five experiments were conducted over a power range of 1.58 to 5.35 watts by mixing increasing amounts of $^{241}AmO_2$ into the plutonium oxide, as shown in Table 1.

Table 1. Material and Power Levels for Temperature Measurements

Experiment#	Weight, Gm PuO_2	Weight, Gm AmO_2	Power Output (Watts) PuO_2	Power Output (Watts) AmO_2	Power Output (Watts) Total	Specific Power (Watts/Kg)
1	760	0	1.58	--	1.58	2.08
2	760	6	1.58	0.55	2.13	2.78
3	760	14	1.58	1.29	2.87	3.71
4	760	26	1.58	2.39	3.97	5.05
5	760	42	1.58	3.77	5.35	6.68

*Model 515-462-00 with ice point thermocouple reference system, variable zero, variable scan capability, readout in millivolts.

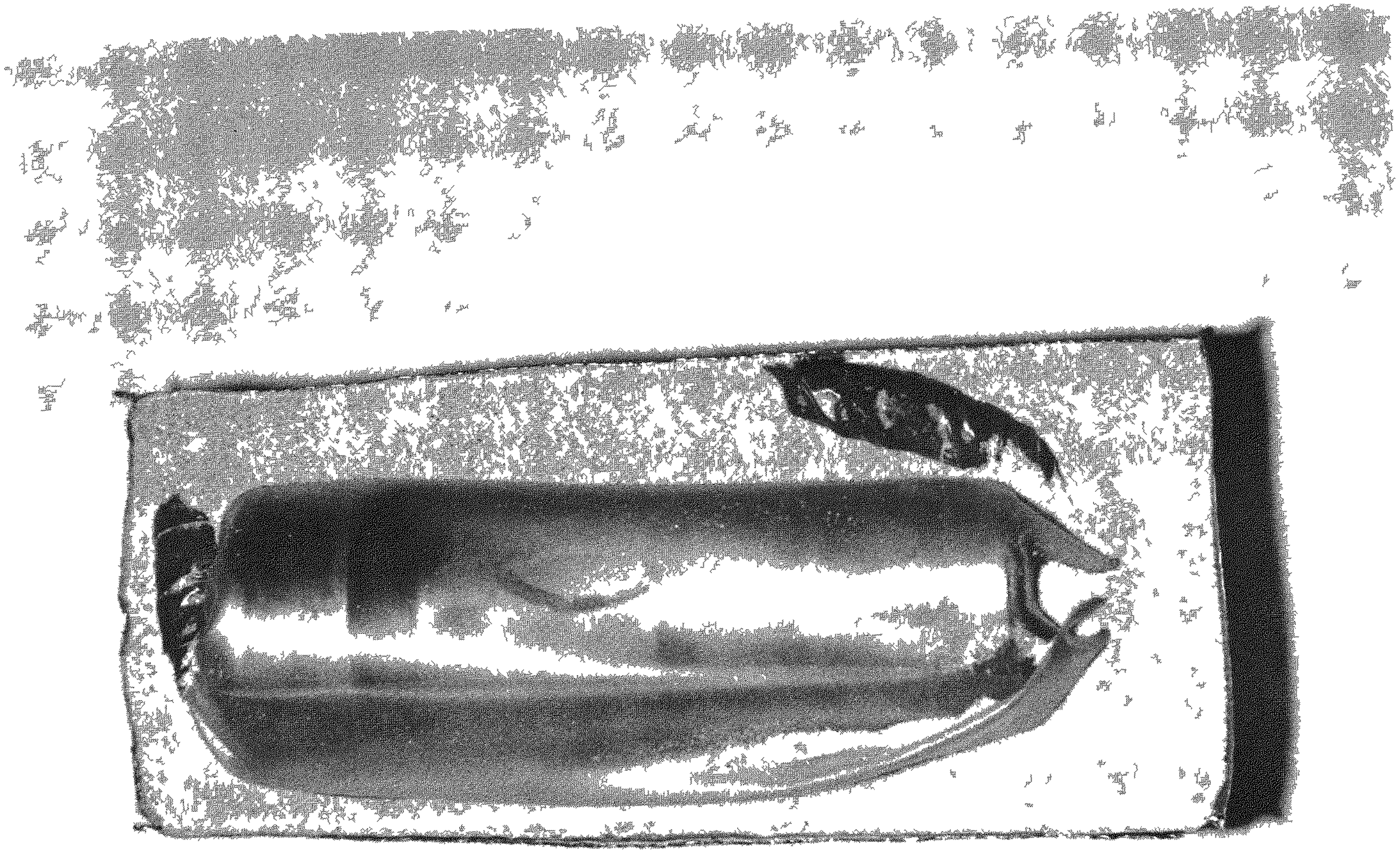

FIGURE 4. Cross Sectional View of Pipe and Sand Inside No. 901 Can

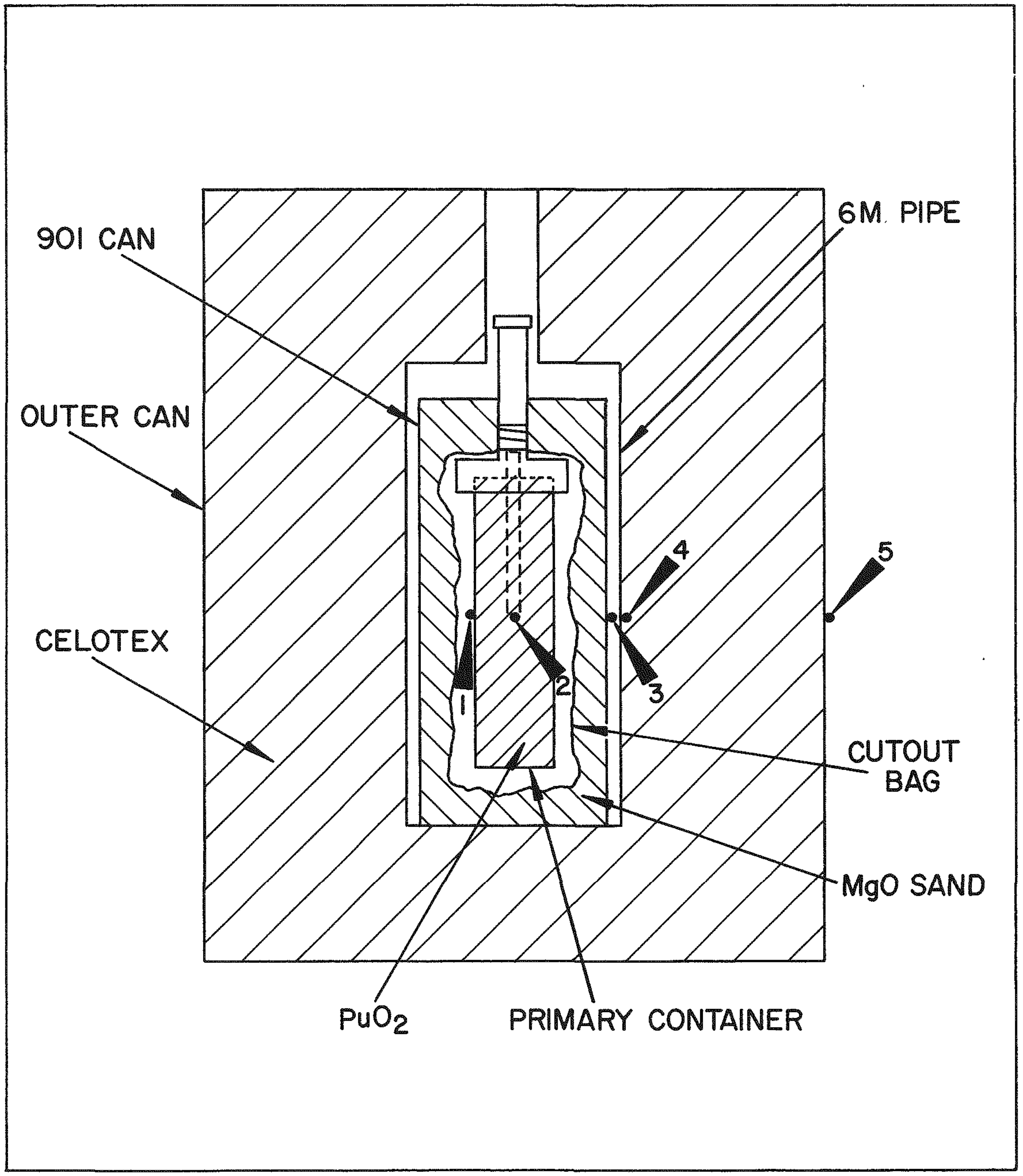

FIGURE 5. Thermocouple Locations for 6M Shipping System Experiment

Equilibrium temperatures were recorded at each power level. After the experiments were completed, the power level of the final mixture (760g PuO_2 plus 41g $^{241}AmO_2$) was measured calorimetrically. Power output was determined to be 5.35 watts, in agreement with the calculated value shown in Table 1.

RESULTS

Equilibrium temperatures, as recorded, are reported in Table 2 and plotted against power input in Figure 6. Ambient temperature was not constant but varied between 70 and 79°F. Although 5-1/2 inches of Celotex insulated the first internal thermocouple, ambient temperature fluctuations appeared to affect a thermal equilibrium for the system. If room temperature did not vary, equilibrium could be reached in 18 to 24 hours.

Table 2. Equilibrium Temperatures in Shipping System

Thermocouple Location	POWER LEVEL (WATTS)				
	1.58	2.13	2.87	3.97	5.35
	TEMPERATURE (°F)				
Inside 1-1/2" pipe	102	111	122	136	163
Outside 1-1/2" pipe	95	105	115	122	148
Outside 901 can	86	93	98	103	110
Outside 6M pipe	82	90	93	97	105
Ambient temp. at equil.	72	78	77	74	74

The same PVC bag was used around the 1-1/2 inch pipe container for all experiments. (The outside of the 1-1/2 inch pipe was kept free of contamination for these tests). The bag was in contact

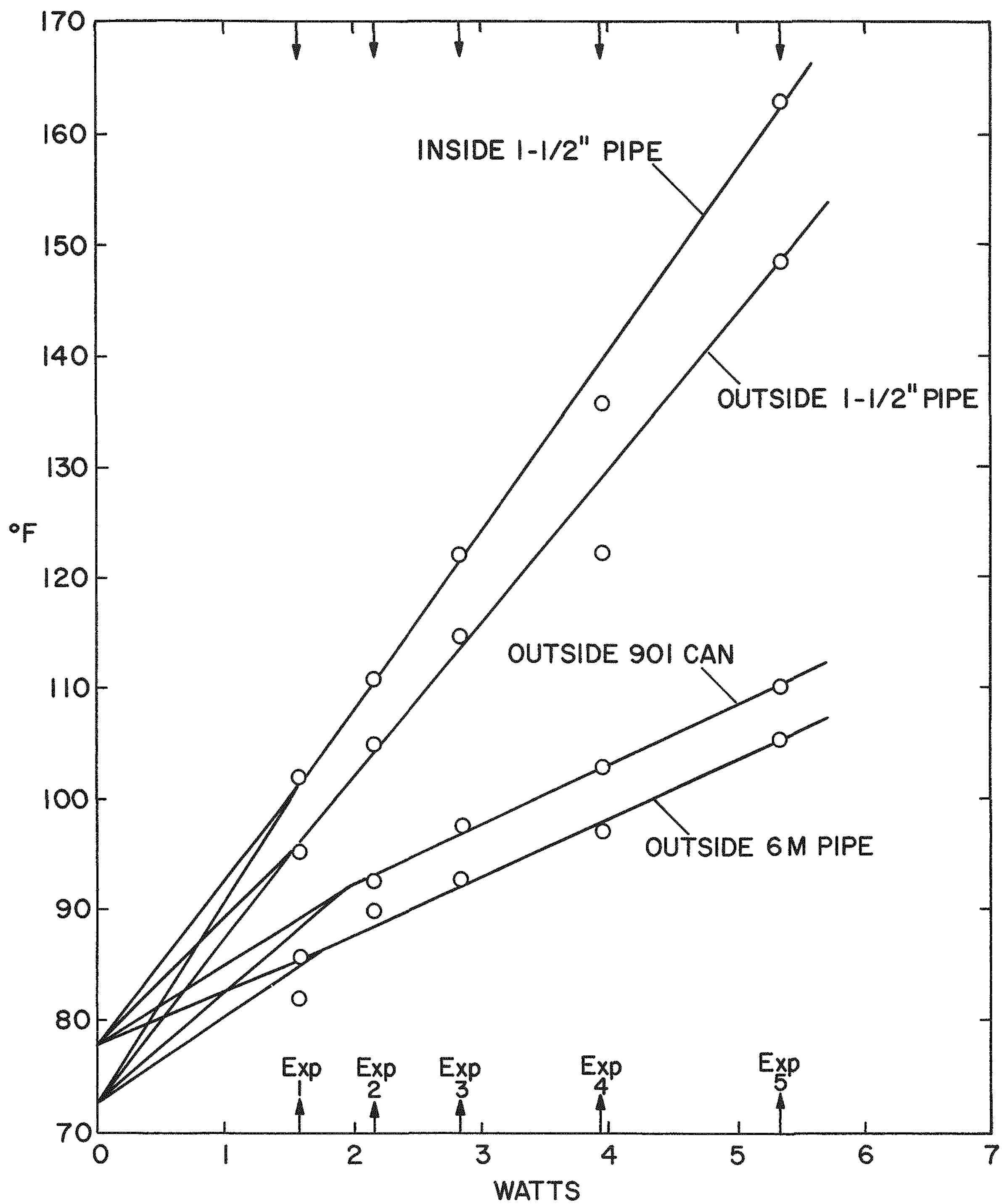

FIGURE 6. Temperature (°F) Versus Power (watts) at Various Locations

with the pipe for over 100 hours at 163°F during the final experiment and for over 200 hours at 136°F during the fourth experiment. Similar contact times, but at lower temperatures, were experienced during the first three runs. The PVC bag did not change in texture, appearance, nor apparent strength as a result of the heat and radiation exposures from these experiments.

DISCUSSION

Plutonium oxides of high specific power output must be dry and free from gas producing compounds to be shipped in sealed containers of the type discussed in this report. Otherwise, outgassing problems causing high pressure buildup could result from the unvented containment.

Prior to the repackaging of power grade plutonium oxide into 1-1/2 inch containers for shipment, heat transfer calculations were performed to approximate the temperature to which the PVC bag might be exposed as the result of utilizing MgO sand. These calculations are presented in the Appendix.

Equilibrium temperatures at points within the system appear to be straight line functions of the power output. Temperatures within the system can therefore be readily estimated. For example, the temperature at the outside of the 1-1/2 inch pipe (contacting the PVC bag) can be predicted as follows:

Let

y = temperature (°F)

Let

x = power (watts),

Slope = 13.75 °F/watts,

Assume ambient temperature = 75°F,

then $y = 13.75x + 75.$

An exposure temperature over 200°F is not recommended for PVC in the presence of radiation. To reach a temperature of 200°F, nine watts would be required. It may therefore be predicted that a power of nine watts could safely be handled by this system without exceeding an exposure temperature of 200°F. Based on results of work by Adcock[2], DOT specification 6M sets a 10.0 watt thermal decay upper heat limit for the 6M system.

Fifteen containers filled with PuO_2 containing 14-16% ^{240}Pu, 2-4% ^{241}Pu, and 530-766 grams PuO_2 per container were successfully shipped from Rocky Flats to Atlantic Richfield Hanford using these containers. Power output was about 2.3 watts per container, well below the 9-10 watt limit.

The PVC bag is the limiting component of this system. Concern for its integrity limits the quantity of radioactive material contained. In long term storage, radiolytic degradation of the PVC must be considered. Polyvinyl chloride in the presence of heat and radiation is gradually dehydrochlorinated to $(-CH{=}CH-)_n$ and hydrochloric acid[3]. If the bag could be replaced by a superior alpha containment material, the size and capacity of the primary container could be increased. Magnesium oxide sand appears to be a good choice for a material to conduct heat away from the primary container.

This system is not intended for storage because of the limited integrity of the PVC bag. The system should be unpacked as soon as practical after receipt. The secondary 901 container should be removed from the insulative atmosphere and stored in an atmosphere conducive to the removal of heat. The contents should be removed from the shipping system within two months of the packing date.

The containment system described appears to be very satisfactory for shipping power grade plutonium oxide. The components used (a threaded pipe container surrounded with MgO sand and sealed in a #901 can) do not require any expensive construction and are very adaptable to the 6M shipping system. The cost of this simple system is very reasonable and the components are readily available. The system can be applied to packaging other high specific power materials. If the power output can be calculated, or measured, temperatures within the system can be predicted from data contained in this report. The concepts of this study can also be translated to the shipping of other materials in other types of shipping systems.

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APPENDIX

Calculations

1. Determination of Power Output of 760g of PuO_2

Data:

Pu assay = 0.870 g/g	Power Output[4] (watts/gram)
^{241}Am assay = 6.56×10^{-4} g/g	^{241}Am = 0.1145
^{238}Pu = 0.011 wt %	^{238}Pu = 0.567
^{239}Pu = 93.708 wt %	^{239}Pu = 0.001931
^{240}Pu = 5.875 wt %	^{240}Pu = 0.007097
^{241}Pu = 0.387 wt %	^{241}Pu = 0.00362
^{242}Pu = 0.019 wt %	--

Contained weight of each isotope times its power output equals its power contribution. Example: contribution of ^{239}Pu = 93.708 x 760 x 0.001931 = 1.375 watts.

Total heat output (summation) for 760g PuO_2 = 1.58 watts

2. Estimate of Temperature (t) Expected at Surface of Primary Pipe Container*

$$q = U_0 A_0 \Delta t \qquad (1)$$

$$U_0 = \frac{1}{\frac{\Delta r_1}{k_1}\frac{A_0}{A_{1m_1}} + \frac{\Delta r_2}{k_2}\frac{A_0}{A_{1m_2}} + \frac{1}{h_0}} \qquad (2)$$

Where:

q = heat transferred by conduction (Btu/hr)

U_0 = outside overall heat transfer coefficient (Btu/hr-ft^2-°F)

A_0 = outside surface area (ft^2) = $2\pi r_3 L_1$ or $2\pi r_3 L_2$

Δt = temperature at surface of primary pipe container, minus ambient temperature (°F)

r_1 = outside radius of primary pipe container (ft)

r_2 = outside radius of 901 can (ft)

r_3 = outside radius of 6M container (ft)

A_{1m} = logarithmic mean area for MgO and Celotex (ft^2)

Δr_1 = thickness of MgO = $r_2 - r_1$ (ft)

Δr_2 = thickness of Celotex = $r_3 - r_2$ (ft)

*The authors appreciate the assistance of Dr. R. L. Sandvig in developing these calculations.

k_1 = thermal conductivity of MgO (Btu/ft-hr-°F)

k_2 = thermal conductivity of Celotex (Btu/ft-hr-°F)

h_0 = film coefficient between outside container and air (Btu/ft^2-hr-°F)

q = 2 watts = 6.83 Btu/hr

Assume: (1) q = 2 watts = 6.83 Btu/hr

(2) To calculate U_0, heat transfer occurs only radially through a cylinder (primary pipe container) of length (L_1).

(3) To calculate Δt (from calculated U_0), increase length of cylinder to total height of Celotex in order to realize a more realistic A_0.

Ambient temperature = 75°F

r_1 = 0.079 ft k_1 = 0.392 Btu/ft-hr-°F

r_2 = 0.169 ft k_2 = 0.0292 Btu/ft-hr-°F

r_3 = 0.625 ft

L_1 = 0.542 ft

L_2 = 1.5 ft

$A_{1m_1} = 2\pi r_{1m_1} L_1$ $A_{1m_2} = 2\pi r_{1m_2} L_1$

Where: $r_{1m_1} = \dfrac{r_2 - r_1}{\ln \dfrac{r_2}{r_1}}$ Where: $r_{1m_2} = \dfrac{r_3 - r_2}{\ln \dfrac{r_3}{r_2}}$

$h_0 \approx$ 5 Btu/ft-hr-°F

From these data:

$A_{0_1} = 2\pi r_3 L_1 = 2.13$ ft^2

$A_{1m_1} = 0.402$ ft^2

$A_{1m_2} = 1.187$ ft^2

$U_0 = 0.034$ (Btu/ft^2-hr-°F)

Using the calculated U_0 to find Δt:

$A_{0_2} = 2\pi r_3 L_2 = 5.89$ ft^2

Δt = 34°F

t = 34 + 75 = 109°F

From experimentally measured values (Figure 6),

$$y = 13.75x + 75$$

Where: $y = °F$, $x = \text{watts}$, $y = 13.75(2) + 75 = 103\text{-}1/2°F$

FUTURE TRENDS IN FREIGHT HANDLING SYSTEMS

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Consultant in Physical Distribution and Marketing

The transportation of radioactive materials are of a particular and special category compared to general freight and even to most commodities. I am not here as a specialist in your particular items, but as one closely involved with the transportation industry as a whole. My aim will be to review the trends of movement and handling systems over the coming decade so that you can relate your specific requirements and developments to the systems and equipment of the future.

After reading some of the material of a previous symposium, several pieces of reference material on radioactive material containers and the program for this meeting, I sense that you are still in the early stages, so far as placing demands upon the transportation industry. In a 1970 report, it was mentioned that 50 motor carriers were transporting most all radioactive material at that time. As the applications and facilities that employ or produce radioactive material grow, you will need to draw upon more segments, more carriers, and more of the equipment and facilities of the transportation industry. Let me, then, speak to the various parts of transportation where your future, if not your present, interests will take you.

This session concerns "standardization" -- needs and progress, and we can discuss the situation in that order, needs, then progress. We should start with the domestic transport system first. Surely, without the complexity of international affairs, we should find a much simpler task than for export or import of materials. Unfortunately, this is not so simple as we might first imagine.

In the continental United States, we have transportation mode alternates that each have opportunities for economic and service use -- water, rail, air, and highway carriers. There are many applications for multi-modal movement among them. Each mode is characterized by individual companies which service limited regions and cities, and nearly half of our shipments require more than one carrier from origin to destination. Efficiencies through standardization of equipment, systems, documents, and regulations are rather obvious. The need is there. How has the industry met this need so far and what of the future?

Standardization in all of these areas is still more a dream than a fact. Take the basic container for motor carriage -- the trailer or "box." The "standard" is a container approximately 8 by 8 by 40 feet attached to a bogie or carriage. But this is not so standard: We have fixed and detachable units of different types; we have lengths of 27, 35, 38, and 45 feet, as well as 40 feet; we have drop-frame or high-cube trailers; and we may soon have widths of 8 feet 6 inches, as well as 8 feet. All of these variations have good reason for being taken as individual decisions; as part of total networks and systems, the differences cause inefficiencies.

Many conditions lead to the variations. Differing state regulations are perhaps the most important. Even a single carrier cannot standardize where he operates interstate. His only way to standardize would be to adopt the maximum limitations of states as his standard, and this would be totally inefficient and uneconomical. If one state allows two 27-foot trailers pulled by one tractor, could a carrier hold to the 40-foot length of a single trailer and thereby "waste" his power units? If one state allows a 45-foot length trailer, can a carrier hold to 40-foot trailers and again waste his power units?

Each carrier must mix even his own road equipment, then, to take advantage of his particular trade-offs. And this indicates the second problem. In our devotion to private enterprise, each company is motivated to take decisions that are most favorable to his own profitability. Motor transportation is characterized by many relatively small firms. There are no strong leaders or trend makers; there is not a substantial program of research and development. Associations are weak and unable to provide even general direction to the industry.

Still holding to only domestic highway carriage, terminals and handling equipment design confront the same problems. Some improvements have been made in internal handling equipment in automatic diverting dragline or towline systems, conveyor sortation, and in motive and accessory equipment for the dock. However, the basic system, methods, and techniques have not really changed in 20 to 25 years. Terminals are larger and more mechanized than they once were, designs are still oriented to handling individual pieces of freight manually through a limited opening at the tailgate of a trailer or truck.

There are major opportunities for improvement within these terminals. The box itself could be moved to a better equipped work station. Handling could be performed from the side with an 8-foot depth instead of from the end with a 40-foot depth. Smaller containers as modules for combination in over-the-road movement could be used. Multi-handling systems could be provided to match more efficiently with individual handling characteristics. But with lack of standardization in the vehicles of movement, company self-interest decisions on the short term; lack of R&D funds and direction; degree of regulation and other facets have, to now, restricted such new and revolutionary concepts.

We can now extend the picture to treat other modes of transportation. Railroads have achieved good interchangeability of rolling stock, if the delays are acceptable. There are some problems of clearance on special cars or loads, but on the whole pretty good, except for trailer or container on flatcar. Here, the diversity is as great as with trucks on the highways. Differences start with trailer <u>or</u> container and continue with variations in loading and unloading systems and tie-down equipment. Air freight has developed astoundingly different containers and handling equipment even when using the same aircraft. Even basic concepts differ widely. Levels of automation are limited; standardization almost nonexistent. Inland water is marked with the same scale of variations. Reasons are not unlike those for motor carriers.

Inter-modal standardization and automation adds a new dimension of problem. The different regulatory bodies in transportation fields make coordination a most intricate task. Real problems, as well as some manufactured ones, have restricted, thus far, even the most basic advancement.

Attitudes in the varying modes further restrict improvement. Like the horse with the car, each mode is not sure the other is here to stay. Arrangements with even clear advantage are not well received by one mode if there is fear that the other mode might gain even as much. Piggyback was widely heralded as an efficient means for long distance motor carriers in the early sixties. Because of intransigence, probably on both sides, motor carriers use rail less now than they did in the early years.

Now let's complicate the picture one step further to international movement. Container size is becoming standardized. The 40-foot box has become nearly standard on captive port-to-port systems or within companies primarily dedicated to ocean movement. Interchangeability with domestic carriers is still limited. Not only are different sizes employed by land carriers, but the trailer versus container rises again. Further, the overall development of ship and port facilities call for stacking of containers, but this requires trailers of different construction than needed for land movement and handling. Perhaps the ocean standardization of a single size is limiting to total economies: increased rehandling, cube waste, limited volumes with the exclusion of shippers who cannot utilize the full box cube.

Specialist carriers form another category in standardization and automation. REA Express took the initiative some years ago to develop high levels of mechanization in their major terminals. At that time they were well ahead of most all others in the transportation industry. Their advantages were that they handled traffic of limited characteristics with special paperwork systems; and had a nationwide closed system where they had relatively little interface with other carriers. In more recent years, this advantage has been lost through internal and external problems.

UPS has picked up the lead in automation in the same way: a closed loop, almost nationwide, system; restricted package characteristics; and simplified paper handling. UPS has designed and standardized equipment and facilities, and reached a good level of mechanization-automation. On a more limited basis, several major air forwarders have made similar accomplishments.

This, in brief, is the present state of technology in the transportation industry. As to progress that we can expect over the next decade, I cannot be optimistic for major and significant forward strides. There will certainly be improvements, but they will be relatively minor in impact on total systems, and many will stand out as isolated cases.

We expect the past trends for acquisitions and mergers to resurface and accelerate in rail and air, but especially in motor transport. There will be fewer and larger carriers. This path will lead to more terminals of the highly mechanized large facilities, but they will be only more evolved versions of terminals now in operation. There will be more consolidated air freight terminals at off-airport locations, but they will not be of greatly different design than today's facilities. By 1980, we expect that there will be a few inter-modal facilities in experimental operation as a result of government studies now under way. There may also be a few terminals for common use of several carriers in the same mode, but these will likely be of limited mechanization, surely not automation.

It would be unrealistic to expect standardization of equipment to increase in any of the transport industries. The political climate will very likely leave highway decisions to the states and different specifications will not narrow appreciably. In spite of mergers, the industry will still be segmented into relatively small companies and interfaces between companies will continue to be a major factor. We do not believe that the current discussions on deregulation will result in any substantial changes. Attitudes and degree of cooperation will not improve enough to make any major breakthroughs. The conflict of regulatory bodies should be largely resolved but the other impediments will continue to resist total transport systems development.

The most basic requirement of automation in physical activities and in procedures is standardization. At best, such standardization is difficult. Rolling stock on rail and highways, and containers for ship and air, have a useful life of 10 to 20 years. A long period is required to phase out old equipment and to use more advanced, more expensive designs in a conventional manner until systems can be turned on. Think of the decision to spend 10 percent more per trailer or container because it will enable increased savings in a system that will be implemented five years later! It takes a patience and confidence that has no present base.

International movement and container ports will probably show the greatest advances in automation over the next decade. You have all read of the new design in ships and systems for containers; of the increasing size and flexibility of ships as in the LASH program; of the huge container ports now being developed. Actually, we now expect more container ports in more locations than was previously imagined. Automation will increase in loading containers both here and abroad. In European and other developed countries, we will see easier movement across country borders of containers and transport terminals that will be able to serve several countries rather than being restricted to one nation. Actually, standardization abroad may increase at a much faster pace in Europe than in the U.S. and the bigger leaps in automation could also be abroad.

There are three trends which we believe will develop during the next decade, which should be of particular interest to you:

> The first is in specialist carriers. There are now, of course, a great number of small common carriers that serve particular commodities, industries, traffic, and especially serve small areas, regions, or one city. Anticipate a development of specialized carriers of greater size and service territory. They will come by mergers and new rights, and they will specialize in particular types of traffic but not as narrowly as most small carriers today. Small shipments, for example, are often rejected directly or indirectly by general carriers. The potential for several large carriers to specialize in freight that takes the next size step to UPS limitations is going to be realized by enterprising companies. Specialist carriers with wide operating rights will also capitalize on the general carrier problems with bulky freight of unusual configuration. In both of these cases, equipment and facilities can be designed for more efficient handling and movement, where limitations are made on freight characteristics.

> The second trend is that of private carriage. Contract carriage will continue to grow but industry opposition to granting of rights will impede widespread applications. As common carrier costs rise disproportionately, even with improved operational efficiency, public carriage rates will also rise greatly. A circle action is created. More firms enter or extend private carriage and take away more profitable carrier volumes; rates rise to compensate; and more companies find private carriage economical. We believe that the private carriage area will increase even more dramatically in the 70's than it has in the past. Private trucking is no longer limited to truckload volumes. The greatest diversion now occurring is larger less-than-truckload shipments -- those of 3,000 to 10,000 pounds. These are also a motor carrier's most profitable size of shipments! Through such methods as consolidations, pool delivery or pickup, and shippers' associations, private fleets are and will increase their in-roads on the for-hire carrier.

The <u>third</u> development over the next 10 years will be in the smaller containers. We have long been advocates of reduced handling through a family of containers -- say of 120, 250, 500, 1,200 cubic feet (compared to a 40-foot van cube of about 2,500 cubic feet) -- either for inside vans or tie-down on flatbed or flatcar. With the increasing labor cost, increased risk of pilferage, rising damage and delay of small shipments, and the interest of new firms in special small container service, we believe that the small container will find its place in transportation during the 1970's. Standardization will be a problem in size, design, material, and interchange for the same reasons as with the van itself. A great deal of shakedown will be required in reaching a total system application, but the benefits will be worth the effort.

In summation, we can see some new developments in transportation during the 70's but, unfortunately, we do not project significant changes in technological design and automation. We see a great need, not only in economic terms, but also in social aspects of use of resources, such as track, highways, land, and manpower. The key to progress is R&D, not theoretical, but practical realistic design and planning for programs that can and will be implemented. In spite of the major study efforts of the Department of Transportation, we do not envision the breakthroughs so greatly needed until there is more real commitment to innovation by the transport industry and its individual forms.

SHIPPING CASKS FOR SPENT FUEL WITH HIGH-BURNUP

R. Dietrich
H. Moryson
F. Schmiedel

ABSTRACT

In a parametric studie, heat removed calculations and neutron and gamma shielding problems are investigated. Fuel elements of a 1000 Megawatt Na-cooled fast breeder-reactor are the basis. The calculations are made for a different number of fuel elements per cask. Shielding material is steel and depleted uranium. The most significant results such as temperatur distribution in the cylindrical wall of the cask and the shielding effect of the steel uranium shielding configuration are shown in different figures.

INTRODUCTION

It is well-known that the burnup of fuel elements for light-water power reactors has increased to a great extent in the last few years and will go on increasing. This leads to such an increase in the quantity of the transplutonium isotopes that the neutron shielding takes on an ever greater significance. In the same manner, the specific heat generation in the fuel elements rises with the higher burnup. The maximum values can be expected with the natrium cooled fast breeder-reactors. The fuel elements of such a reactor, nameley a 1000 Megawatt natrium cooled fast breeder-reactor, were based on the following tests. The element data is listed in Table 1.

Table 1. Datas of the fuel elements[1]

Overall length	3700	mm
width over flats of hexagonal nut	176,5	mm
weight	315	kg
fertile material	65	kg
fuel material	72	kg
decay heat generation rate	55	kW

Two subjects were examined:

1. Temperature distribution in shipping casks
2. Shielding of shipping casks

whereby casks for 1, 3, 5 and 7 fuel elements were used for the calculation.

The casks are cylindrical in shape. The length of the cask depends on the length of the fuel elements. The cross-section of the casks for 1, 3, 5 and 7 fuel elements can be seen from Fig. 1. For the heat removal calculation, a cask construction from the inside to the outside was taken having 2 cm steel, 12,5 cm uranium and 4 cm steel.

The outer cask is fitted with metal cooling pins 100 mm in length and 12 mm diameter.

HEAT REMOVAL CALCULATION

Calculation method

Each cask comprises several cylinder layers having almost the same heat conductivity value. The inner heat source is taken as distributed homogenously through the inner volume. NaK in the cask is taken as heat transfer agent. Lid and bottom of the cask are considered as insulated. The temperature distribution over the cask length was not taken into account. A segment of 5 cm thickness is cut out of the cask and used for the calculation. This segment is subdivided into 100 to 170 volumen elements for the temperature distribution calculation using the TOSS-code.

Calculations carried out

a) Temperature distribution in the shipping cask for spent fuel for natural convection and mechanical cooling

b) Temperature distribution after a 30 minute fire test at 800°C for natural convection and mechanical cooling.

All calculations were carried out for 1, 3, 5 and 7 fuel elements.

In the case of mechanical cooling an air stream of 10 kg/sec in the pinned cylindrical part of the cask was adopted. In the case of the fire test the baffle plate of the mechanical cooling works partially as insulation.[5]

Results

Figs. 2 and 3 show the temperature distribution of the different cask variations for natural convection, mechanical cooling and fire test.

The results are compiled in Fig. 4. Curves 1 and 2 show the maximum central temperature for the hottest fuel element depending on the number of fuel elements in the case of natural convection and mechanical cooling; curve 3 the maximum surface temperature of the cask in the case of mechanical cooling. Curves 4 and 5 show the maximum central temperatures of the hottest fuel elements during fire test under natural convection and mechanical cooling. Lower temperature values are obtained in the case of mechanical cooling because of the outer air feeding jacket acting as an insulating wall.

If one takes as a base the permissible of
80°C for the max. permissible surface temperature
700°C for the max. permissible central temperature
800°C for the max. permissible central temperature during the fire test,
then it can be seen that the limit of the max. permissible surface temperature is reached first.

SHIELDING CALCULATIONS

Initial data

The shielding effect for a steel-uranium shielding configuration was calculated. Neutrons and gamma radiation were taken into account. The inner steel layer (20 mm) and the outer steel layer (40 mm) were kept constant, since this is necessary for reasons of strength and handling. The uranium thickness was varied between 50 mm and 200 mm.

The generation of secondary gammas was not taken into account.

In Table 2 and 3 the neutron source strength and gamma source strength for one fuel element with a burnup of 80 MWd/kg are compiled.[1.2] The gammas were based on a decay time of 100 days.

Calculation procedure

The calculations were carried out for a slab geometry. The configuration comprises three material layers infinitely expanded in two dimensions.

The cross-sections of the shielding material were compiled for the neutrons with the aid of the ANISN program, for the gammas with the aid of the MUG program, in each case for 16 group energy structures.

For the mentioned group energy structures the neutron and gamma flux was calculated with the ANISN program as a function of the location.

The primary neutron and gamma dose results from the flux at the outer surface of the shielding.

Results

Fig. 5 shows the dose of the neutron and gamma flux before snielding in dependence on the number of fuelelement. It can be seen that the gamma dose is higher by the approximatly factor 10^3 than the neutron dose. The break in the curve can be put down to the same cask geometry with 5 and 7 fuel elements. In Fig. 6 the neutron and gamma dose behind the shielding for

1, 3 and 7 fuel elements is shown as a function of the shielding capacity (uranium). The expected sharp fall of the gamma dose in dependence on the uranium thickness and the essentially weaker shielding effect for neutrons can be clearly seen.

The total dose rate behind the shielding is decisive for the design of the cask. As per Fig. 6 there are 3 ranges:

a) Gammas determine the shielding
b) Neutrons and gammas determine the shielding
c) Neutrons determine the shielding.

When the neutrons determine the shield thickness an additional neutron shielding (not uranium) will, of course, be used.

Fig. 6 clearly shows that even slight changes in the neutron dose and/or gamma dose can severely change the shielding conditions.

Fig. 7 indicates the required uranium layer thickness for 1, 3, 5 and 7 fuel elements for the max. permissible dose of 200 $mrem \cdot h^{-1}$.

Fig. 8 shows the cask weight of the cylindrical part per cm cask length.

Conclusion

1. A heat transfer medium such as sodium or potassium is necessary inside the cask.

2. A forced cooling on the outside of the cask is necessary if we look for a economical shipping.

3. The maximum number of fuel elements per cask will be between 3 and 5.

4. Depleted uranium is from the theoretical point of few a very attractive shielding material. Especially for fast breeder elements, with a harder fixed source spectra - as shown in Table 2 - it seems to be of some advantage. We feel, that we can spare about 20% in weight and this is importand for the road-transportation.

5. Some investigations are necessary on the overall economy of the use for depleted uranium. The price of depleted uranium and the difficulties in manufacturing must be taken into account as well as the advantage in weight.

Table 2. Neutron spectrum of the fuel element[1.2] (burnup 80 MWd/kg)

Energy group	Energy range				Neutron flux $n \cdot FE^{-1} \cdot s^{-1}$
1	10,00	-	14,92	MeV	0,0
2	6,70	-	10,00	MeV	$1,218 \cdot 10^5$
3	4,07	-	6,70	MeV	$6,44 \cdot 10^5$
4	2,47	-	4,07	MeV	$1,274 \cdot 10^6$
5	1,35	-	2,47	MeV	$1,85 \cdot 10^6$
6	0,821	-	1,35	MeV	$1,341 \cdot 10^6$
7	0,407	-	0,821	MeV	$9,27 \cdot 10^5$
8	0,202	-	0,407	MeV	$3,995 \cdot 10^5$
9	0,111	-	0,202	MeV	$1,558 \cdot 10^5$
10	40,9	-	111	KeV	$6,1 \cdot 10^4$
11	9,12	-	40,9	KeV	$2,71 \cdot 10^4$
12	0,961	-	9,12	KeV	0,0
13	0,101	-	0,961	KeV	0,0
14	10,70	-	101	eV	0,0
15	3,06	-	10,7	eV	0,0
16	1,13	-	3,06	eV	0,0
17	0,414	-	1,13	eV	0,0
18	0,0	-	0,414	eV	0,0

Table 3. Gamma spectrum of the fuel element[1,2]
(decay time 100 days, burnup 80 MWd/kg)

Energy group	Energy range	Gamma flux $\gamma \cdot FE^{-1} \cdot s^{-1}$
1	8,0 - 10,0	0,0
2	6,0 - 8,0	0,0
3	5,0 - 6,0	0,0
4	4,0 - 5,0	0,0
5	3,0 - 4,0	0,0
6	2,0 - 3,0	$2,33 \cdot 10^{11}$
7	1,50 - 2,0	$2,04 \cdot 10^{11}$
8	1,25 - 1,50	$1,166 \cdot 10^{13}$
9	1,00 - 1,25	$1,415 \cdot 10^{13}$
10	0,80 - 1,00	$1,001 \cdot 10^{12}$
11	0,60 - 0,80	$1,495 \cdot 10^{16}$
12	0,50 - 0,60	$2,835 \cdot 10^{13}$
13	0,40 - 0,50	$5,33 \cdot 10^{15}$
14	0,30 - 0,40	$6,73 \cdot 10^{12}$
15	0,20 - 0,30	$5,20 \cdot 10^{15}$
16	0,10 - 0,20	$2,55 \cdot 10^{15}$
17	0,05 - 0,10	$4,43 \cdot 10^{14}$
18	0,02 - 0,05	$6,07 \cdot 10^{15}$

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FIGURE LIST

Caption

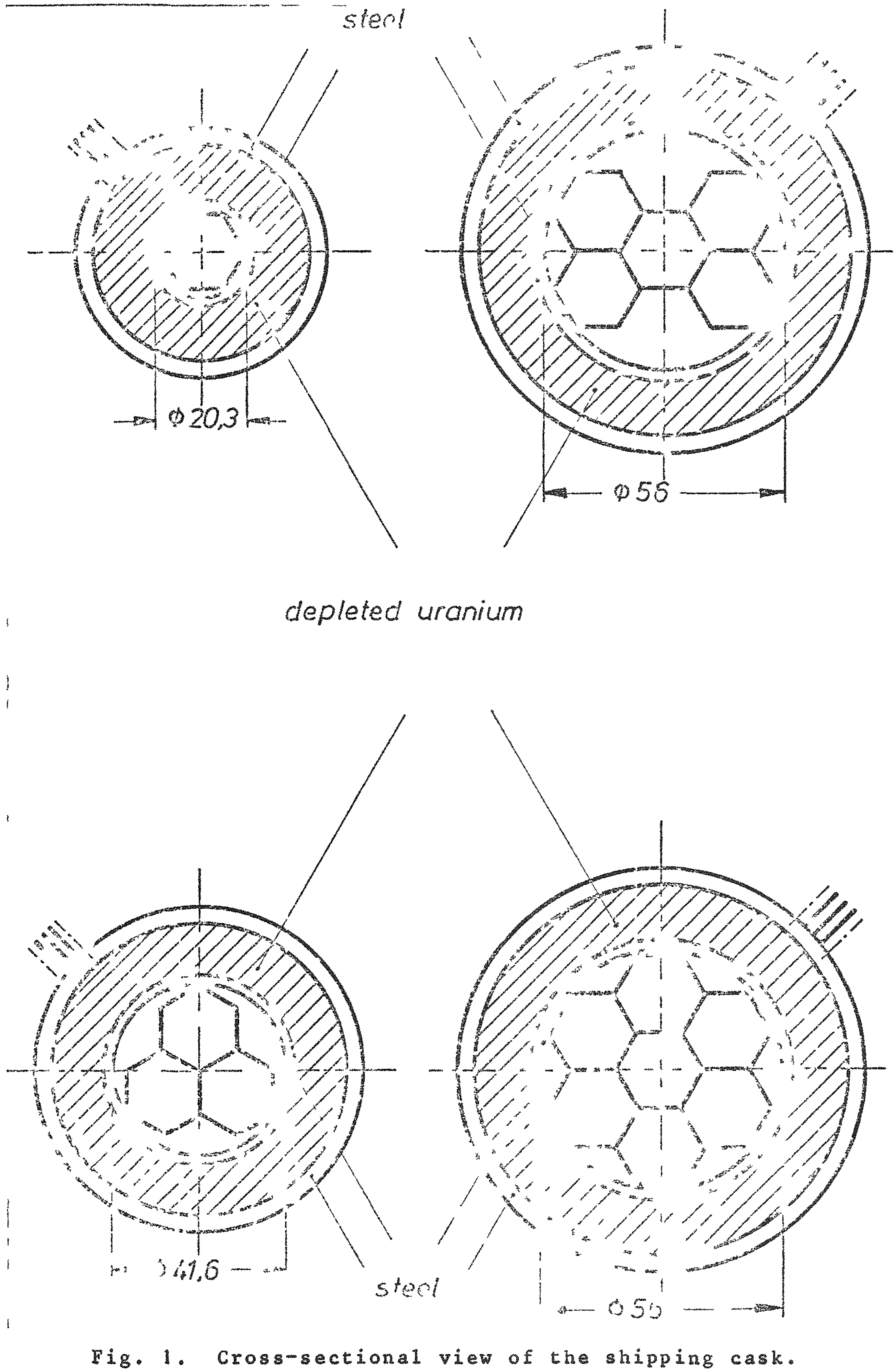


Fig. 1. Cross-sectional view of the shipping cask.

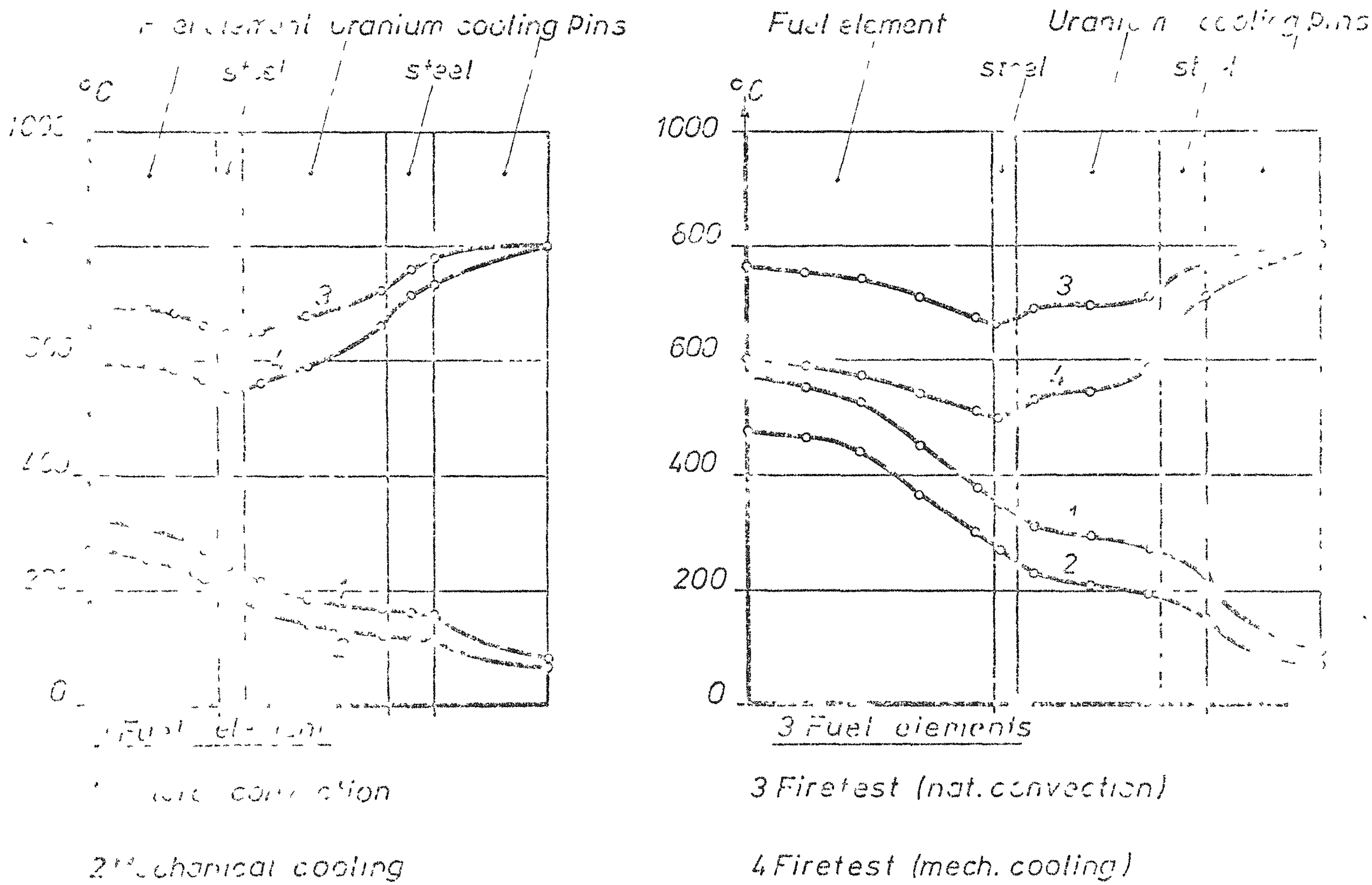


Fig. 2. Temperature distribution in the cylindrical wall

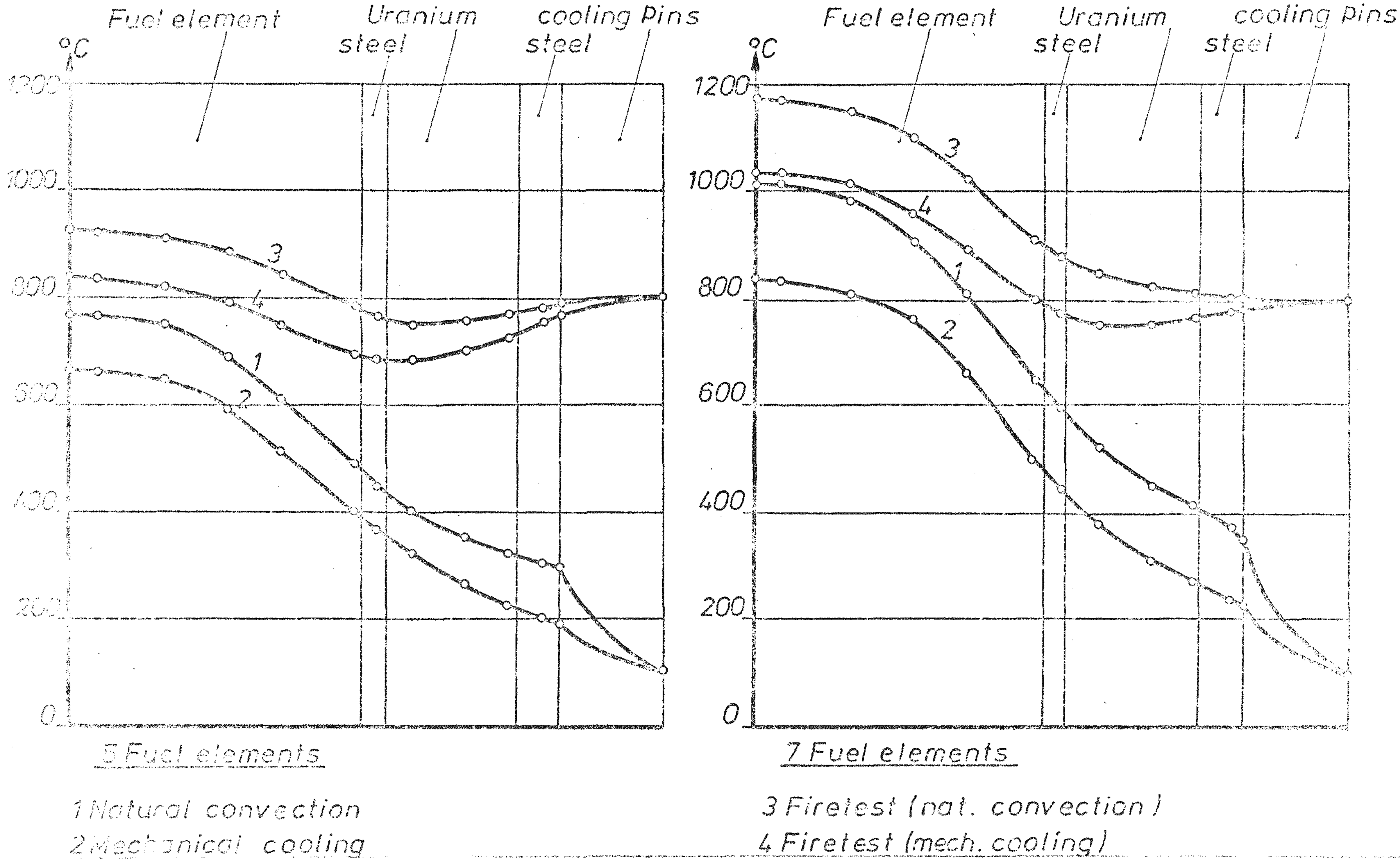


Fig. 3. Temperature distribution in the cylindrical wall

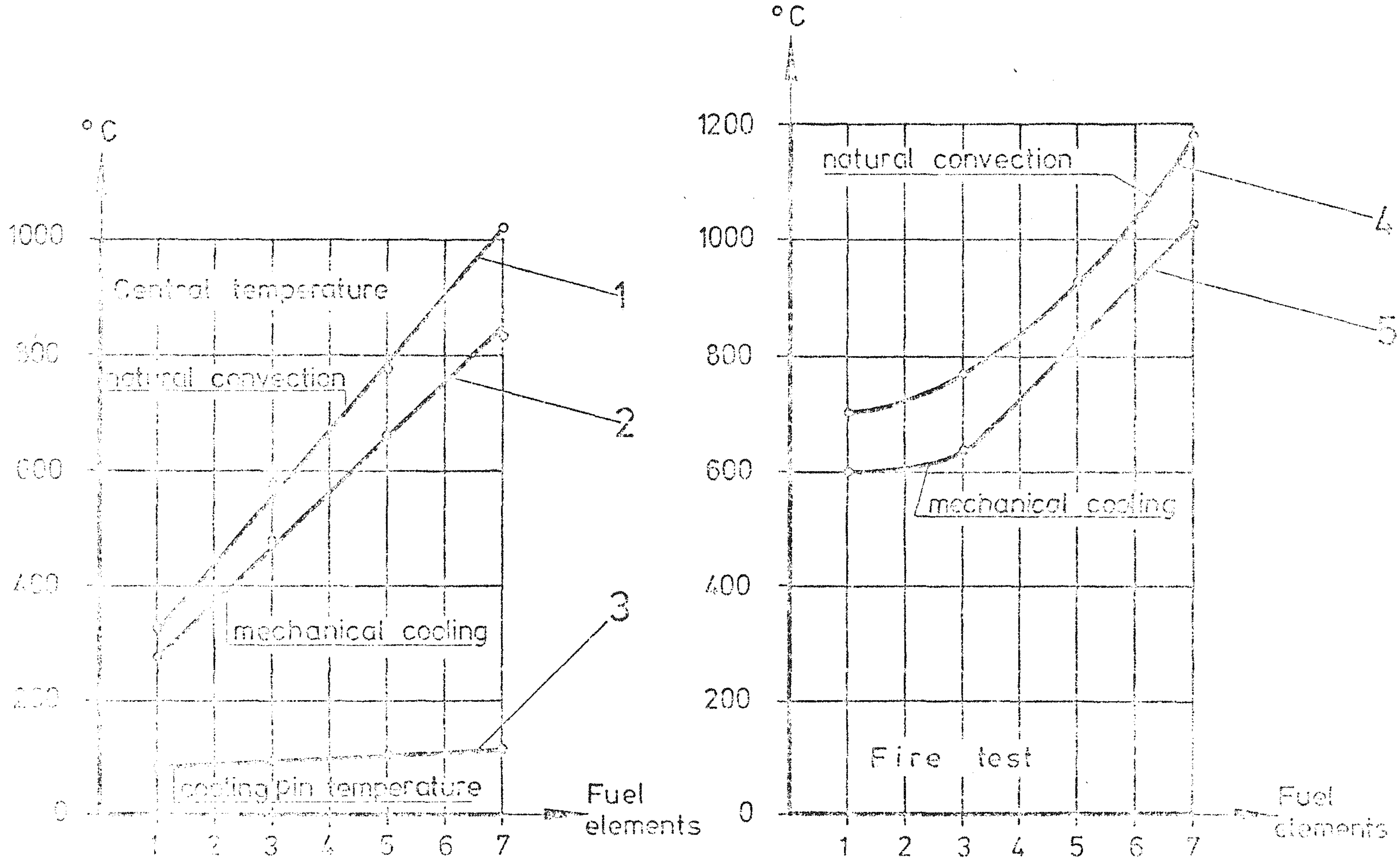


Fig. 4. Maximum Temperature on the critical points of the shipping cask.

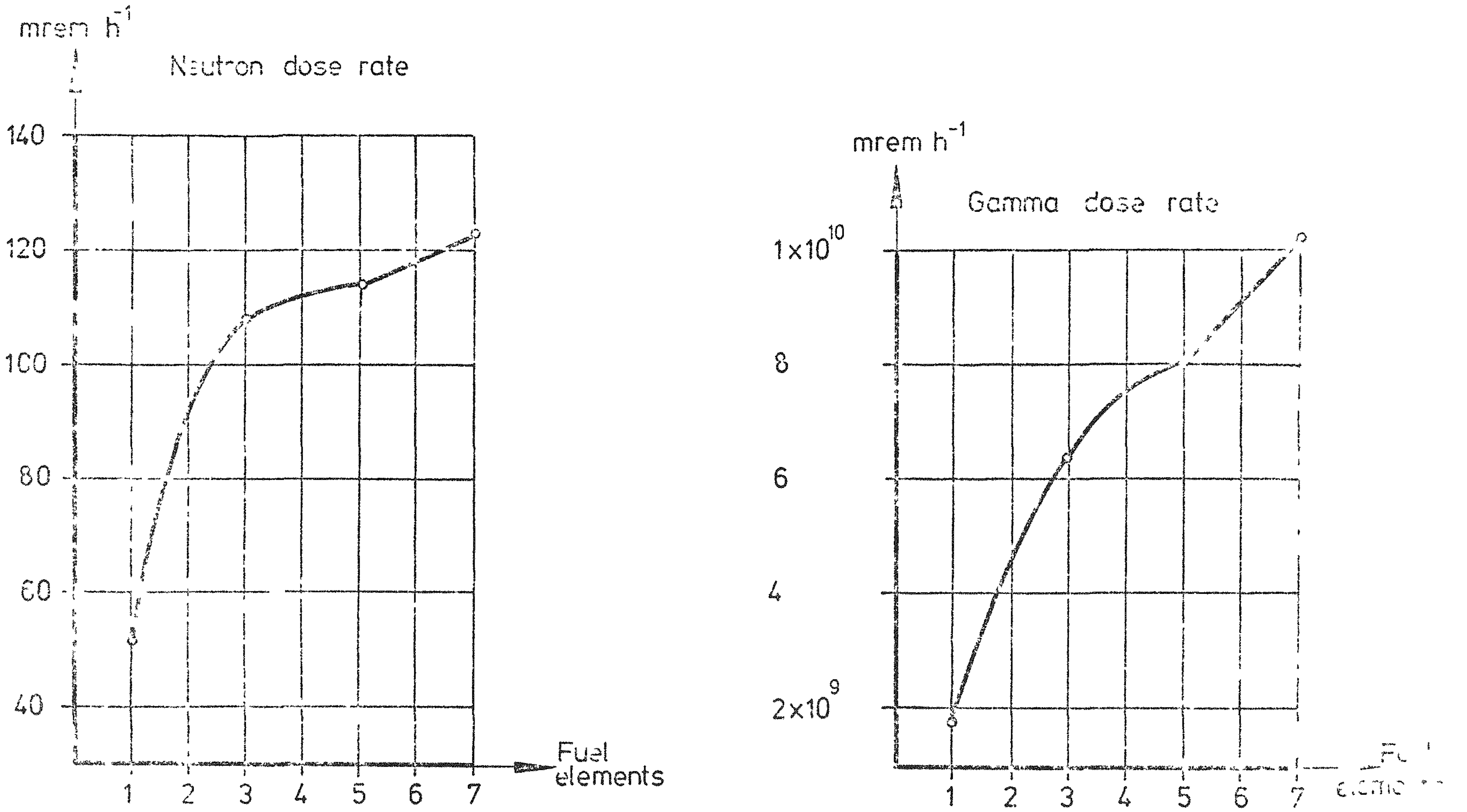


Fig. 5. Neutron and Gamma dose rate before the shielding configuration

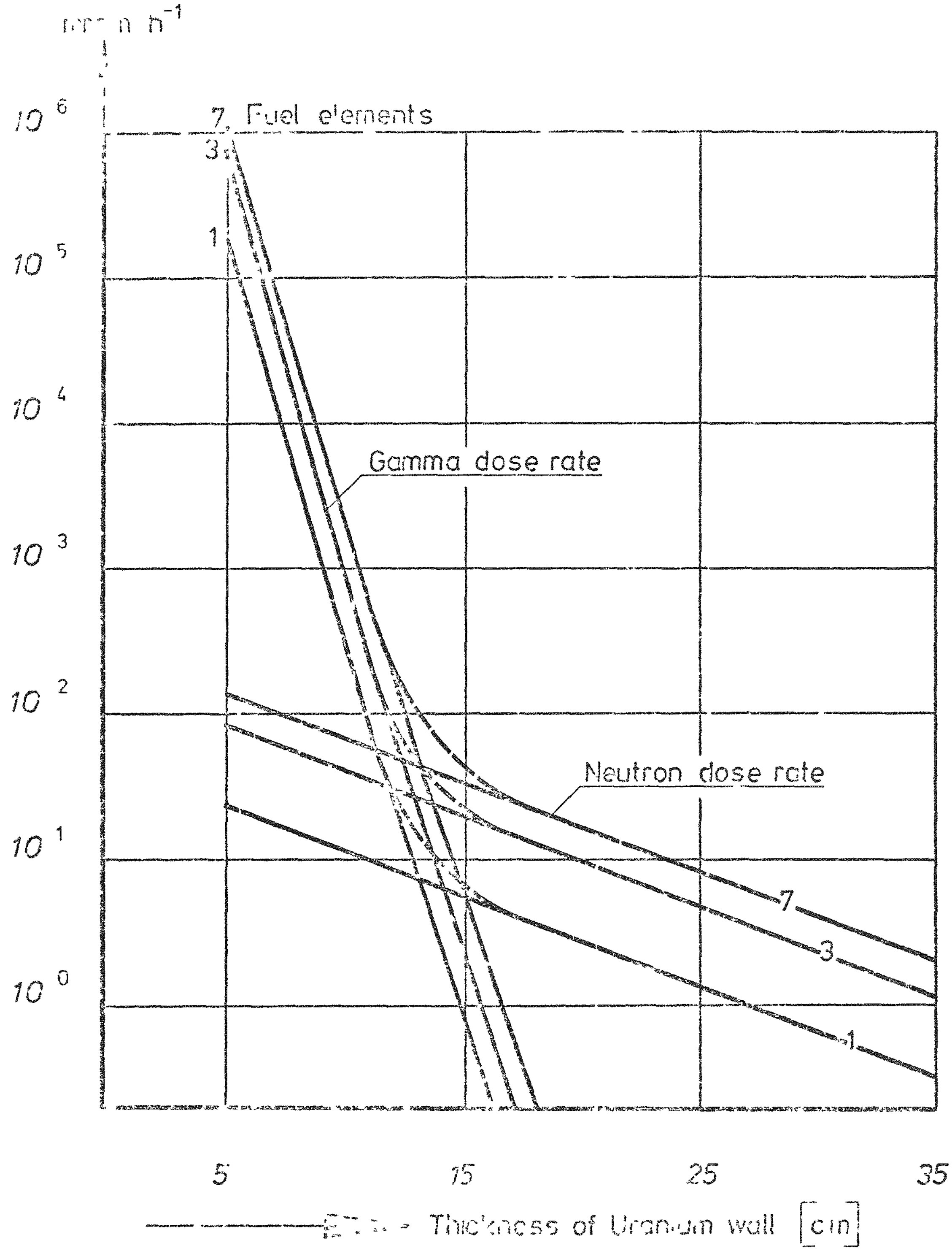


Fig. 6. Total dose rate as a function of Uranium wall thickness

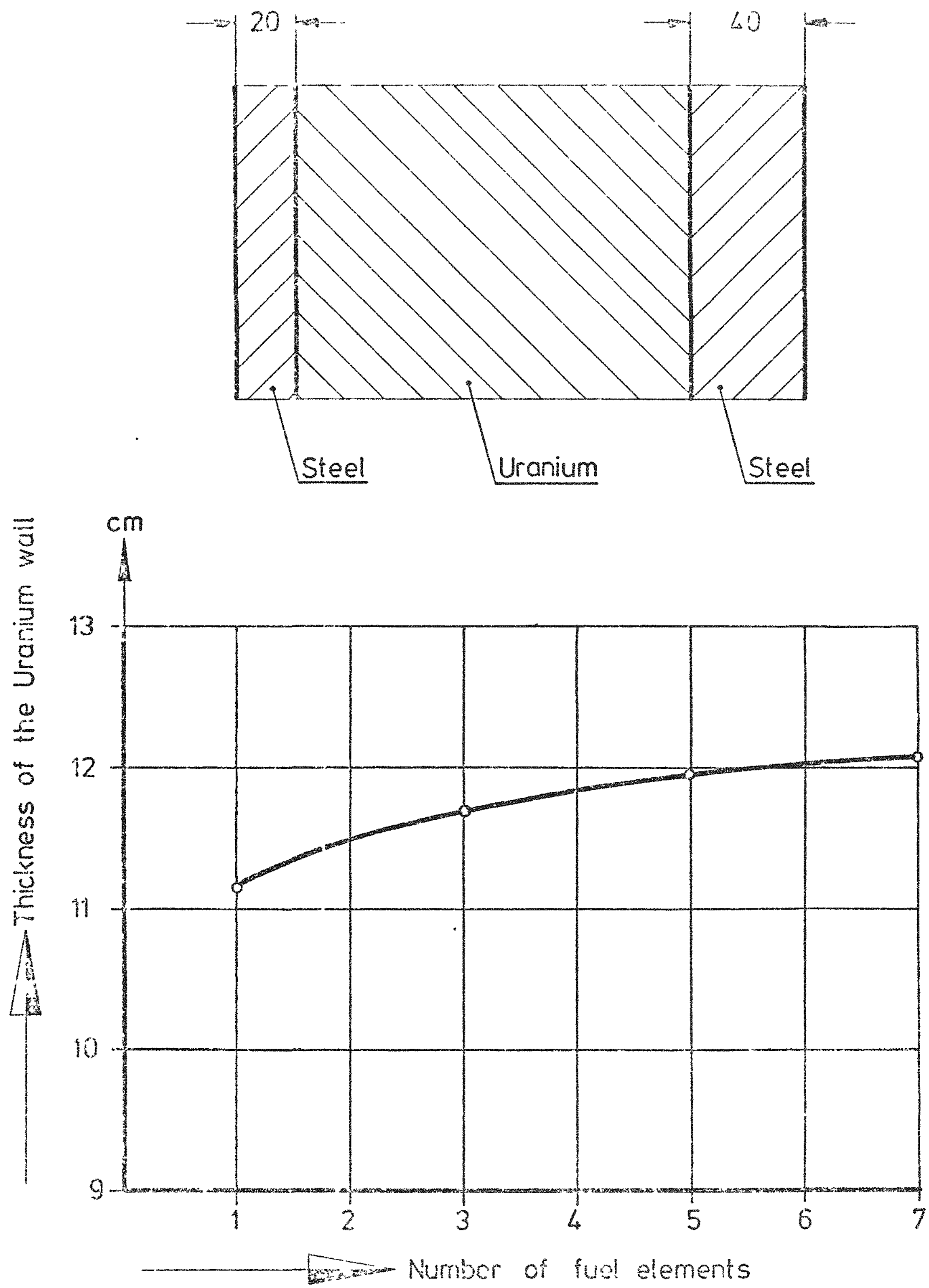


Fig. 7. Required Uranium layer thickness for 200 mrem h^{-1}

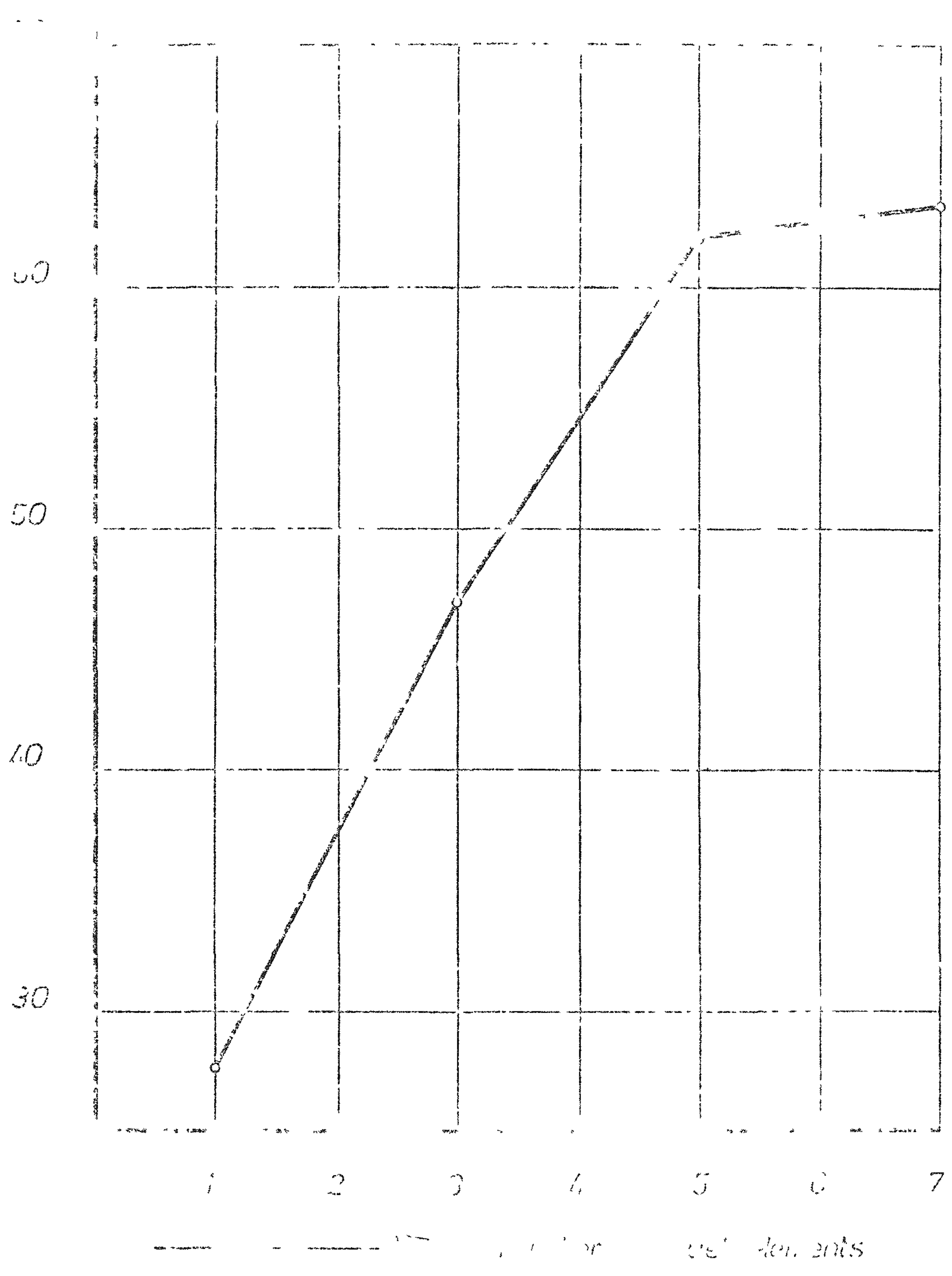


Fig. 8. Cask weight of the cylindrical part per cm
Cask length (dose rate 200 mrem h^{-1})

GENERAL ELECTRIC COMPANY
IF 300 SPENT FUEL SHIPPING CASK
DESIGN EXPERIENCE

R. H. JONES AND C. W. SMITH

INTRODUCTION

The General Electric IF 300 spent fuel shipping cask illustrated in Figure 1 is the end product of a design program which from concept to completion took approximately three years of intensive work.

This design is primarily a rail transported cask. However, the system has provisions for over-the-road movement to service those reactor sites that do not have a rail siding. This highway movement is only from the reactor site to the nearest suitable railroad location where the cask is loaded onto its railcar using a modified "piggyback" technique. This intermodal shipment configuration is illustrated in Figure 2. The loading facility is illustrated in Figure 3.

Figure 4 shows the cask itself. As illustrated, the structure consists of two stainless steel shells surrounding depleted uranium metal shielding. One unique feature of the cask is its corrugated water jacket. This stainless steel structure provides containment for the neutron shielding medium and also presents a large area for the dissipation of heat. The continuous convolutions also create a smooth surface which will greatly reduce the decontamination time. Since the jacket is only 1/8 inch thick, it does not add significantly to the cask weight, although the corrugations make the jacket structurallv quite rugged.

Another unique feature is the forced-air exterior cooling system, which efficiently removes large amounts of decay heat without requiring the closed loop/heat exchanger devices of other large casks.

The IF 300 cask holds either 18 BWR or 7 PWR fuel assemblies. This is accomplished with interchangeable baskets and heads. The cask itself weighs approximately 65 tons and the total package weighs about 85 tons.

With this brief description of the present equipment, I would like to trace the cask design from its concept and, perhaps, highlight a few significant things which led to the present configuration.

Chronology

Concept

The IF 300 cask scope design was begun in early 1968. The basic design

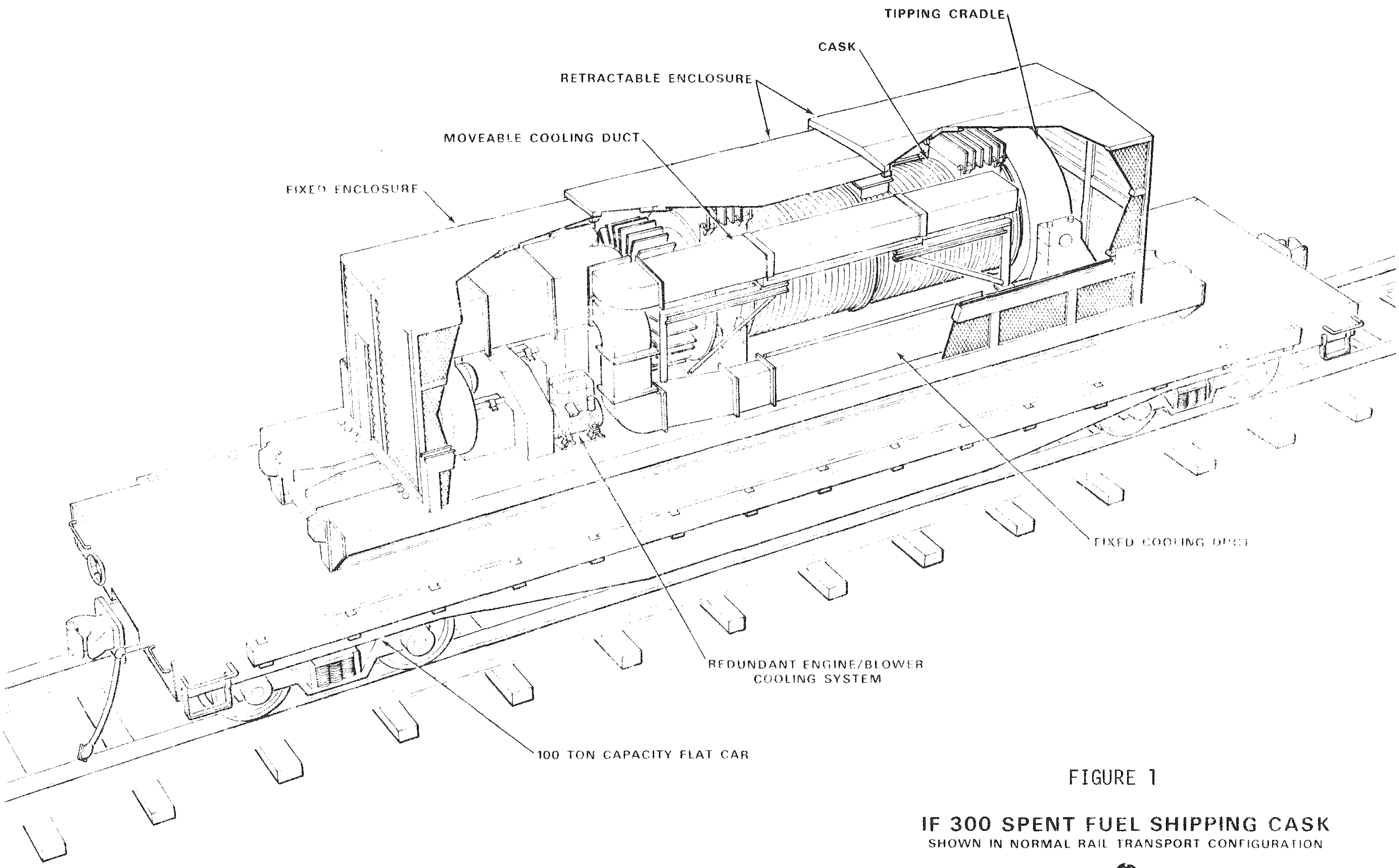


FIGURE 1

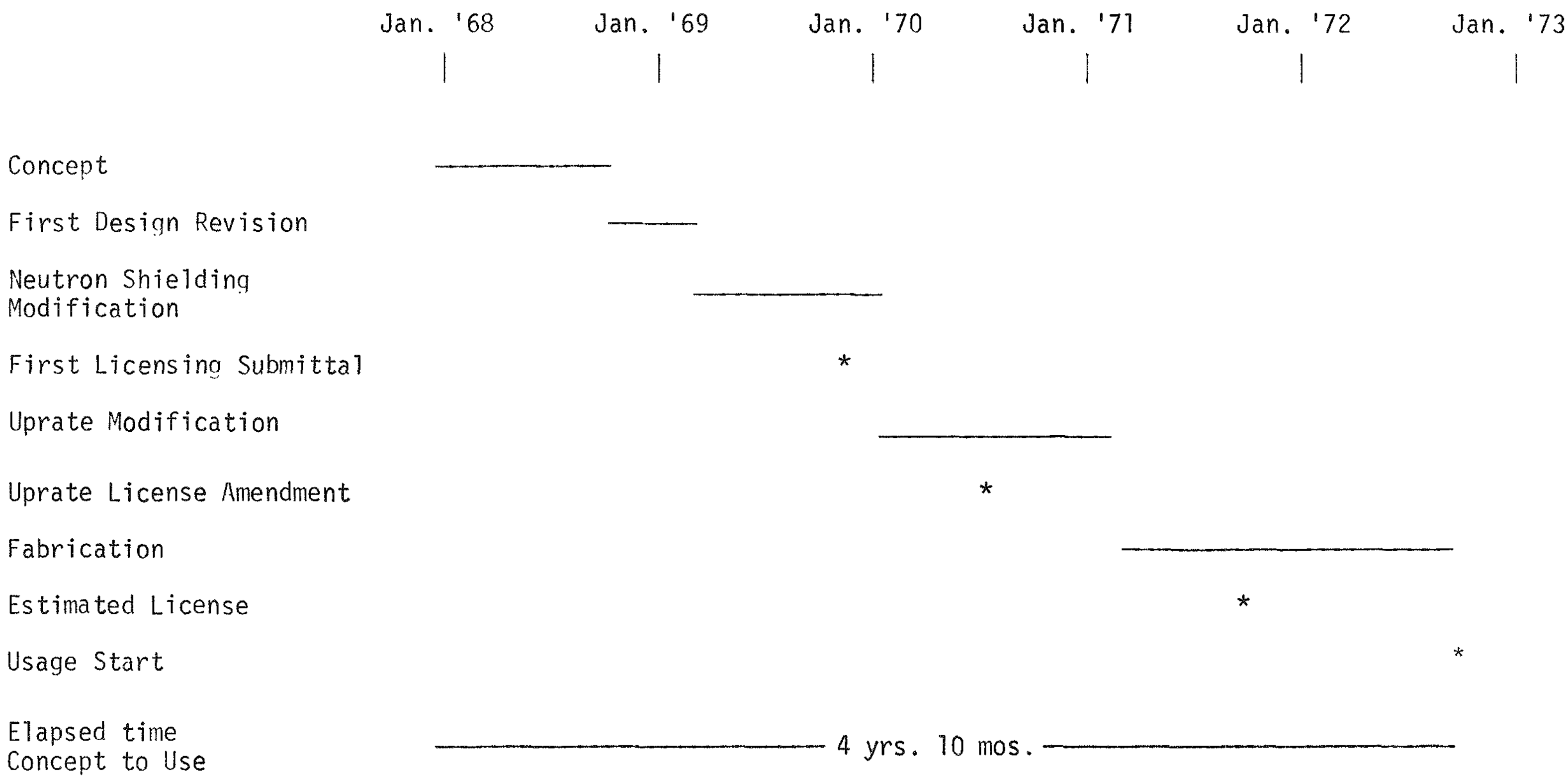
IF 300 SPENT FUEL SHIPPING CASK
SHOWN IN NORMAL RAIL TRANSPORT CONFIGURATION

GENERAL ELECTRIC

TABLE 1

COMPARISON OF SHIPPING CASK DESIGN FEATURES

Item	IF 100 and IF 200	IF 300
1. Gamma shielding	Lead	Depleted uranium
2. Neutron shielding	None	External hydrogenous liquid (primarily water)
3. Impact energy-absorbing members	None	Fins on side and ends
4. Cooling system	None	Forced air on cask exterior
5. Internal pressure protection	Rupture disk	Combination breaking pin and pressure relief valve
6. Criticality control	None required	Boron carbide rods attached to cask internals
7. Cask internals	Single-element fuel basket	Multiple (7 to 18) element interchangeable fuel baskets
8. Cask supports	Mounted on transporting trailer deck	Skid mounted to form a unitized package
9. Protective enclosure	None	Three section, telescoping structure which locks to prevent access
10. Transportation mode	Legal weight or overweight truck	Primarily rail with the capability of over-the-road movement for short distances to service plants without rail facilities
11. Flexibility of usage	Limited due to cavity length (140" max.) and lack of neutron shielding	With interchangeable heads and baskets, this unit can ship all present and planned light-water reactor fuels. Very flexible design



IF 300 CASK

ELAPSED TIME CHART

FIGURE 5

AN ECONOMIC AND ENGINEERING ANALYSIS OF A UNIT TRAIN CONCEPT FOR THE TRANSPORTATION OF SPENT FUEL ASSEMBLIES FROM COMMERCIAL NUCLEAR POWER PLANTS

A. G. Trudeau

D. E. Haagensen

ABSTRACT

The construction of a large number of large commercial nuclear power plants in the United States in the coming decade will present some interesting and difficult problems with respect to the transportation and handling of spent nuclear fuel assemblies from these utility plants to reprocessing plants. It appears that, where practicable, a unit train concept for the complete shipment of spent nuclear fuel assemblies from a particular plant on an annual basis may be not only the safest and fastest, but also the most economical means of transportation. It is also evident that the problem of the attenuation of neutrons from spent fuel assemblies with high burnup rates requires the development of greatly improved casks. In this connection the problems of safe and rapid handling also favor the development of designs and techniques that eliminate the need for raising and lowering very heavy casks in and out of the spent fuel pools.

INTRODUCTION

Our purpose here is to present an analysis of the potential for transportation by a unit train concept of spent fuel assemblies from commercial nuclear power plants to commercial reprocessing plants in the United States. Much work remains to be done on our concept and we welcome your suggestions.

The unit train concept involves the complete shipment from a plant on an annual basis of the spent fuel assemblies, in one trip, with a thirteen to sixteen special car train. This is a fundamentally new concept as we believe there are limitations to truck haul. However, this concept of a unit train encompasses associated shipment by truck and car float or barge transportation. There are three fundamental points of importance: Safe transport, plant safety, economics and time.

First, we believe that it is necessary to have an AEC-licensed transportation service that is an integrated system of over-the-road, rail, and/or water modes of transportation. Consideration of only rail shipment or only over-the-road tractor-trailer shipment is simply not practical in view of the fact that approximately 25% of the nuclear plant sites as of 1970 do not have both rail or road facilities. There are several nuclear plant sites that require intermodal transportation by means of water, rail, or water/over-the-road methods of shipment.

As of now, all 50 states of the United States have existing legal limitations of Gross Carrier Weights of 73,280 lbs. (An excellent pamphlet on maximums in truck transportation will be available to you through the courtesy of North American Rockwell with whom I am associated.) Only two states have slight modifications, permitting overlength tractor-trailers of special weight limitations. It is both impractical and illogical to assume the various regulatory authorities of the 50 states will modify their existing legal weight limits from 73,280 lbs. to 115,000 lbs., or even 90,000 lbs., as recommended by a large, important nuclear association. A single bridge may be the limiting factor. It is also necessary to recognize the legal limitations related to transportation of hazardous materials on special turnpikes and thruways over the highway systems in the 50 states.

On top of it all, of course, are the requirements of the AEC and the Department of Transportation, which are presently being explored. The questions of safety will be magnified by the Naders and others as they become more acute, and the delays caused the Army during the recent movement of some old stocks of toxic gas clearly indicate the difficulties that may lie ahead.

Second, the Advisory Committee on Reactor Safeguards of the Atomic Energy Commission has questioned the safety aspects of handling a 100-ton shipping cask in the area of the spent fuel pool of both PWR and BWR third-generation plants. In one case the conclusion was reached that in the event of an accident, where the spent fuel cask was dropped, the result would be dewatering the spent fuel pool. In each case this distinguished committee recognized a serious problem in handling a massive spent fuel cask in the plant. On the other hand, our patent has an essential difference in that only a relatively lightweight shielded canister is handled in the vicinity of the spent fuel pool. (This patent will be discussed in more detail later.)

The report of the Advisory Committee on Reactor Safeguards has also questioned a number of private utility companies pursuant to an accident wherein a 100-ton shipping cask might be accidentally dropped in the refueling area adjacent to the spent fuel pool. They stated that in several cases technical information indicated that with a 100-ft. drop of a 100-ton cask, the integrity of the cask would be seriously jeopardized upon impact. The matter of handling a damaged load cask is certainly a challenging one.

Third, to achieve the most economical shipment of spent fuel assemblies it is necessary to complete the total shipment per year from each plant to the selected reprocessor in a time period of less than 30 days. This cannot be accomplished if shipments from our large plants are to be handled with massive casks. Here again our concept permits the preshipment of unloaded shielded canisters to a private utility company for preloading in the spent fuel pool. The complete shipment, therefore, of the total number of spent fuel assemblies per year may be scheduled and administered in the required time period of 30 days or less per year. This appears to be essential if the refurbishing cycle is to be held to one year.

Furthermore, a specific utility company may desire to ship its annual load of spent fuel assemblies for reprocessing as a "batch process" to a commercial reprocessing plant. The spent fuel material is so valuable for the uranium and the plutonium content that a particular utility company may not want its "recovered" materials mixed with the materials of another commercial nuclear power plant. The burnup rates may be different and, therefore, the value of the uranium and plutonium content may be quite different. Transuranium contents may also be different as the plutonium recycle fuels are utilized in the late 1970s and thereafter.

An economic and engineering survey, documented in 53 individual reports and completed during the latter part of 1968 and early part of 1969, established the basic interest of private utility companies in a fixed-price contract for transportation of nuclear spent fuel assemblies. This transportation service for shipment in shipping casks licensed by AEC encompasses truck, rail and water transportation from the private utility plant to a commercial reprocessing plant selected by the utility company. Without exception, each company expressed an opinion this type of contract with a five-year period of time was, indeed, satisfactory and desirable.

The rental service of an integrated unit train, truck and barge transportation system is predicated upon several fundamental points:

1. The shipping cask will be licensed in accordance with the regulations of the Atomic Energy Commission, Washington, D.C.

2. Each shipment of spent fuel assemblies requires a shipping permit issued under the regulations of the Department of Transportation, Washington, D. C.

3. The fixed-price rental contract will be subject to both upward and downward price redetermination dependent upon variation in direct labor costs and established labor rate indices.

4. Prepayment of part of the total rental charge will be a clause in the rental contract.

5. Expert and detailed liaison carefully administered at all times concerning all matters of regulations with the staffs of the AEC and DOT, Washington, D. C., Oak Ridge, Tenn.

SECTION I. FORECAST OF SPENT FUEL ASSEMBLY SHIPMENT - COMMERCIAL NUCLEAR POWER PLANTS

A press release of the Atomic Energy Commission, Washington, D.C., the International Nuclear Industry 1968, contains a basic estimate of installed nuclear capacity of approximately 150,000 MW(e) by 1980. This publication also states that in the period 1965 to 1968 approximately 92 commercial nuclear power plants were ordered, representing approximately 65,000 MW(e).

The AEC report also states, in view of the fact a five-year period is required from the ordering of a plant to operation, there will be an additional 85,000 MW(e) capacity of plants ordered in the next several years.

As of this date, there are, in addition to the 114 commercial nuclear power plants built or under way, approximately 6 small nuclear demonstration plants built and operated in association with the Atomic Energy Commission and the private utility industry.

Accordingly, the forecast of spent fuel shipments represents approximately 92 large commercial nuclear power plants and the additional number of approximately 100 to be ordered in the next several years. Our forecast of spent fuel shipment is based upon a transportation company securing contracts with approximately 40% of the total number of plants. The following table represents factual material for the two basic size plants; namely, 800 MW(e) and 1,000 MW(e). (Table 1)

SECTION II. NUMBER OF CASKS, CARS, AND UNIT TRAINS

The analysis of the required number of AEC-licensed shipping casks, cars and number of unit trains is based upon detailed information obtained from the indicated survey and the authentic publication of the U. S. Atomic Energy Commission, WASH-1082, entitled, "Current Status & Future Technical and Economic Potential of Light Water Reactors," dated March 1968.

The objective of this analysis is to determine the number of nuclear power plants that may be serviced by a unit train.

It has been determined that nuclear power plants are base load plants and will operate without interruption during eleven months of a year wherein both of the peak load periods are found. Thus there will be one month of each year during which the unit train may not be utilized to transport spent fuel assemblies but, in fact, may be utilized for other purposes including fuel sharing.

Cask - Gross weight - 30 tons

Shielding Material - Depleted uranium

Loading - 2 spent fuel assemblies either 800 MW(e) or 1,000 MW(e) plants. PWR type

P W R - 800 MW(e) Plant

Type	52 fuel assemblies per year
	2 assemblies per cask
	26 cask loads per year
	2 casks per car
	13 car unit train
	1 control car

Table 1. Forecast of Spent Fuel Assemblies

Year	Number of Plants	800 MW(e) Plants (A)	1,000 MW(e) Plants (B)	Fuel Assemblies per year (A)	Fuel Assemblies per year (B)
1973	35	25	10	25 x 52	10 x 64
1974	50	35	15	35 x 52	15 x 64
1975	55	40	15	40 x 52	15 x 64
1976	60	45	15	45 x 52	15 x 64
1977	65	45	20	45 x 52	20 x 64
1978	70	50	20	50 x 52	20 x 64
1979	70	50	20	50 x 52	20 x 64
TOTAL FUEL ASSEMBLIES.				290 x 52	115 x 64

1. 800 MW(e) plants - 515 x 290 x 52 = 7,766,200 Kg of UO_2
2. 1000 MW(e) plants - 515 x 115 x 64 = 3,790,400 Kg of UO_2
3. Total Kilograms of UO_2 = 11,556,600

This total value of kilograms of UO_2 is the value to be used in the later calculation of the depreciation charge for the required shipping casks.

(The above table was based on PWR type plants, as stated in AEC Report--1082--Civilian Nuclear Power. The slight difference with a mix of PWR and BWR plants would actually not materially modify the facts of the table.)

P W R - 1,000 MW(e) Plant

64 fuel assemblies per year

2 assemblies per cask

32 cask loads per year

16 car unit train

1 control car

Number of Plants Serviced per Month - Unit Train

400 miles to reprocessor - assumed distance

400 miles return (empty) - " "

800 miles - 3 days via rail

For 800 MW(e) plant - 26 cask loads

For 1000 MW(e) plant - 32 cask loads

6 hours loading and unloading time per cask - utility site and reprocessor

For 800 MW(e) plant $\frac{26 \times 6}{24} = \frac{156}{24}$ = 6 days approximately

For 1000 MW(e) plant $\frac{32 \times 6}{24} = \frac{192}{24}$ = 8 days approximately

For 800 MW(e) plant - 3 plus 6 = 9 days for round trip

For 1000 MW(e) plant - 3 plus 8 = 11 days for round trip

Therefore, one unit train may service 2-3 plants per month, with a 1-3 day allowance for loading or shipping delays.

A unit train may, therefore, service 25-30 plants per year, based upon a conservative basis of 1 1/2 months per year for fuel sharing and train maintenance downtime.

The following tabulation assumes the first train and casks will be ready for operation in the latter part of 1972. Five-year rental contracts signed with the private utility companies or the commercial reprocessors. The number of plants is indicated in the following chart. (Table 2)

It is to be noted that a particular private utility company will have, in the great majority of cases, more than one plant; for example, Philadelphia

Electric Company has now authorized four nuclear power plants. The number of plants in the tabulation from 1973 to 1980 represents approximately 40% of the total number of planned, authorized and operating commercial nuclear power plants. The Edison Electric Institute projection of new plants is adhered to for the years of 1977, 1978 and 1979.

Table 2. Requirement of Unit Trains and Shipping Casks

Year	Number of Plants	Number of Trains	Number of Casks	Number of Cars
1973	35	2	60	30
1974	50	2	60	30
1975	55	2	60	30
1976	60	3	90	45
1977	65	3	90	45
1978	70	3	90	45
1979	70	3	90	45
1980	70	3	90	45

The above tabulation (Table 2) indicates that to service 70 commercial nuclear power plants and remove on an annual basis their spent fuel assemblies will require a total number of three unit trains. Each train will have on the average fifteen cars and a special control car. Each car will have two thirty-ton shipping casks. The total number of shipping casks required therefore is 90.

SECTION III. COST AND SELLING PRICE OF RENTAL SERVICE OF UNIT TRAIN

The analysis of the cost and selling price for the rental service of a unit train and associated spent fuel shipping casks must necessarily include all of the factors of direct and indirect costs. There have been numerous technical articles in Government publications, and otherwise, wherein only th direct costs of the shipping casks and the freight charges have been taken into consideration. This analysis includes for the items of direct and indirect cost, the following factors:

Depreciation period of AEC-licensed shipping casks - 7-1/2 years.

Depreciation period of tractor-trailer power unit - 15 years.

Depreciation period of barges - 15 years.

Depreciation period of unit train - 15 years.

Administrative cost of engineering supervision.

Burden cost 25% - Net Profit 10%

It is also necessary to carefully state the basic parameters for the depreciation rate per year. The depreciation information is summarized as follows:

Unit Train, Barges, Tractor-Trailer Power Units - 15-year life:

Depreciation	6.7% per year
Return on Investment, Federal Income Tax	17.0% per year
Insurance and Real Estate Tax	2.5% per year
Total Depreciation	26.2% per year

AEC-Licensed Shipping Casks - 7-1/2 year life:

Depreciation	13.6% per year
Return on Investment, Federal Income Tax	15.7% per year
Insurance, Ad Valorem Taxes	2.5% per year
Total Depreciation	31.8% per year

The depreciation of the cost of the shipping casks represents a major item of cost. The depreciation charge per cask is based essentially upon the number of kilograms of UO_2 contained in the spent fuel assemblies based upon a seven-to-eight year depreciation period. The value of total kilograms of UO_2 for the seventy plants is given in Section I and is based upon authentic information of the number of plants and the associated number of spent fuel assemblies.

Depreciation of Shipping Casks:

Number of Casks	90
Weight of Casks	30 tons
Cost per pound	$5.00

Total Cost - 90 x 60,000 x $5.00 = $27,000,000

Depreciation Period	7-1/2 years
Depreciation Rate	31.8% per year

Depreciation Charge - $27,000,000 x .318 = $8,586,000 per year

Depreciation Charge per Kg of UO_2 =

$\frac{\$64,395,000}{11,556,000}$ = $5.57 per Kg of UO_2 of a spent fuel assembly.

The transportation service requires, of course, a unit train with its AEC-licensed shipping casks. The depreciation of the unit train cost is stated as follows:

Depreciation of Unit Train Cost:

1 unit train - 15 cars on the average

1 control car for each unit train

3 unit trains - 45 cars and 3 control cars

Unit Train Estimated Cost.	$ 1,800,000
Total Train Cost (3)	$ 5,400,000
Depreciation Period	15 years
Depreciation Rate	26.2% per year
Depreciation Charge (3 trains)	$1,414,800

The rental income and net profit potential for an 800 MW(e) plant and a 1,000 MW(e) plant may be calculated using the above basic information. The gross rental income and net profit potential are calculated as follows:

For an 800 MW(e) Plant - Annual Shipment of 52 Spent Fuel Assys.--Rail:

(a) Depreciation Charge for Unit Train Cost:

Train Cost (3) — $ 5,400,000

Depreciation Rate — 26.2% per year

Depreciation Charge - $\frac{\$1,414,800}{70}$ = $20,211

(b) Administrative Cost of Train Supervision and Scheduling:

50 employees

$1,000,000 per year total cost

$\frac{\$1,000,000}{70}$ = $14,280 per plant per year

(c) Freight Cost - 1 Unit Train Annual Round Trip:

Distance - 800 miles

Time - 3 days

13 car train

26 casks - 30 tons each - Total cask weight - 780 tons

Cost per 100 lbs. - 800 miles = $0.70 per 100 lbs. of cask weight

Cost of trip - 780 x 20 x $0.70 = $10,920

(d) Depreciation Charges for Cost of Shipping Casks:

Unit Train - 13 cars per 800 MW(e) plant and 1 control car

52 Fuel Assemblies - 27,040 Kg of UO_2

Depreciation Charge - 27,040 x $5.57 = $150,612

Cost and Selling Price - Rental Contract - 800 MW(e) Plant --Rail:

Direct Cost =

(a)		(b)		(c)		(d)		
$20,211	+	$14,280	+	$10,920	+	$150,612	=	$196,023

Direct Cost	-	$196,023
*Overhead - 25%	-	49,005
		$245,028

*Overhead - 5% G&A
5% Sales
15% Contingency

Cost and Selling Price - Rental Contract - 800 MW(e) Plant - Rail: (Cont.) -

Subtotal	-	$245,028	
Profit 10%	-	$ 24,502	
Selling Price	-	$269,530	for annual shipment of 52 spent fuel assemblies of 800 MW(e) plant - $9.97 per Kg of UO_2.

For a 1,000 MW(e) Plant - Annual Shipment of 64 Spent Fuel Assys. -- Rail:

The cost is within 3% of the same figure; slightly less, in fact.

Consequently, for shipments east of the Mississippi we estimate a norm of $10.00 per kg.

SECTION IV. PRELIMINARY ENGINEERING ANALYSIS OF THE TRUDEAU-HAAGENSEN INTEGRATED SHIPPING SYSTEM FOR IRRADIATED NUCLEAR FUELS

I will ask Mr. Darrow Haagensen to discuss the subject with you now.

In 1970 the Southern Interstate Nuclear Board, Atlanta, Georgia, conducted a Southern Governors Conference on Transportation of Nuclear Spent Fuels on February 5 and 6. Their excellent publication, CONF-700207, presents authentic information concerning planned methods of shipping irradiated fuels. The discussion of the Trudeau-Haagensen cask and shipping system has reference to several of the articles in this publication of SINB.

The article on total shipping requirements by J.D. McDaniels, Jr., of Nuclear Fuel Services, Inc., Rockville, Maryland, presents an illustration of a tractor-trailer combination with a 58,000-lb. container designed to carry one PWR fuel unit. The combined gross carrier weight is stated as about 90,000 lbs., with 16,000 lbs. of axle weight and 10,000 lbs. on the steering axle. The BWR version, Mr. McDaniels states, was slightly increased gross carrier weight by an additional 10,000 lbs., or a total of 100,000 lbs. combined gross carrier weight.

SINB Report also contains the report of Mr. James W. Lee, Transportation Consultant of SINB. His report presents, per Figure 9, a shipping cask of 80,000 lbs. and a gross carrier weight of 115,000 lbs. The shielded cask would contain two type PWR fuel assemblies, or four type BWR assemblies. The maximum single axle load is stated as 18,000 lbs.

Both of these studies and reports indicate a method of transportation wherein the maximum gross vehicle weight is in excess of the present legal weight limit in the 50 states. The present limit is 73,280 lbs.

The Trudeau-Haagensen cask and integrated shipping service system was predicated upon careful study on the existing literature in this very rapidly developing area of a safe and economical shipping service, taking into consideration several basic factors.

First, we believe it prudent to design an over-the-road transportation system wherein the gross carrier weight is not in excess of 73,280 lbs. We believe it is not feasible to plan for future transportation with weight limits in excess of this value because it is our informal opinion the 50 states will not legally modify their presently stated weight limits.

Second, a careful review of the technical literature, including the publications of the several Divisions of the Atomic Energy Commission and its legally authorized Committees, has indicated questions pertaining to the safety of handling a 100-ton cask both over the spent fuel pool and adjacent to the spent fuel pool of the utility site. We were of the opinion it was necessary to design a partially shielded subassembly or canister to be placed in the water of the spent fuel pool for preloading of the spent fuel assembly by the staff of the utility company. This canister or subassembly would be designed to weigh not in excess of three to four tons, including the weight of a single PWR fuel assembly of approximately 1,500 lbs.

Third, we are of the opinion it is necessary to complete the fuel cycle of 800 to 1,100 MW third-generation light-water moderated nuclear plant on an annual basis. Our staff has thoroughly examined a number of Preliminary Safety Analysis Reports of various utility companies which indicate these important nuclear power generation units are planned as base load units with a single maintenance period per year. There will be one complete plan shut-down for preventive maintenance operations and refueling. Our objective, therefore, was to adhere to this principle, with the preloading of the shielded subassemblies and, whenever possible, the application of the unit train principle. The shipping time for the complete load of spent fuel assemblies would be done in a single shipment with a total period of time of 30 days or less. This period of time would include all of the operations of loading, shipping, and unloading the complete number of spent fuel assemblies at the reprocessing plant specified by the private utility company.

Our staff has considered the legal requirements of both the Atomic Energy Commission and the Department of Transportation, Washington, D. C., pursuant to the requirements of safety of transportation and licensing of the shipping casks. Our staff has noted these requirements of Part 71, Title 10, Atomic Energy of the Code of Federal Regulations, and Parts 171 through 178 of Title 49 of the Code of Federal Regulations. In addition, our staff has noted the technical requirements specified in the ASME Boiler and Pressure Vessel Code, Sections 2 and 3, as well as other authentic engineering standards of ASTM.

Our design concept has recognized the technical parameters of the PWR and BWR fuel assemblies of the presently operating and planned 400 to 1100 MW(e) ratings. In particular, for a PWR assembly as recently stated in a request for proposal of a reprocessing company, the following parameters are listed:

Fuel Assembly	
Cross section dimensions, inches	8.576

Fuel Assembly	
Overall length, inches	170
Active Fuel Length, inches	150
Fuel Assembly Overall Weight, pounds	1600
Minimum Cooling Time, days	120
Replacement Fuel Enrichment, w/o U-235	3.58
Average Equilibrium Burnup, MWD/MTU	35,000
Average Specific Power, Kwt/KgU	37.0
Hot Assembly Average Specific Power, Kwt/KgU	44.4

Corresponding parameters with reference to a type BWR fuel assembly are taken into consideration in the engineering analysis of our staff.

The Trudeau-Haagensen concept of an integrated shipping service has been presented to you by General Trudeau of over-the-road, rail, and water methods of shipment as required by the siting areas of the private utility company plants. Figure 5 presents the cask concept of the patent applied for. As with any patent application, the illustration is presented and discussed in a general fashion. Figure 5 does not represent a final design or a final cross section of an AEC-licensed shipping cask.

The purpose of this discussion is to briefly present the salient points of concept of design. The shipping cask, for example, for over-the-road shipment will comply with the gross carrier weight limits of 73,280 lbs. and allow the shipment of two type PWR spent fuel assemblies. The characteristics of these spent fuel assemblies have been mentioned previously in the text of this presentation. A corresponding related number of type BWR spent fuel assemblies will be loaded into the shipping cask of the weight limits as stated.

The basic principles of design are noted in Figure 5 and Figure 6, wherein a partially shielded subassembly, Item 28, of a weight of approximately 2.5 to 3.0 tons is utilized for preloading in the spent fuel pool. This partially shielded subassembly, Figure 6, Item 28, is illustrated with a stainless steel interior and exterior construction, Items 36 and 40 with the utilization of depleted uranium, Item 32, for the attenuation of the gamma rays emanating from the spent fuel assembly.

This partially shielded subassembly, Figure 6, will have a removable end cap in one of the two ends. The unit will be placed in the shipping cask, Figure 5, within cask subassembly, Item 48. The loading may be from a horizontal position with folding doors in the area of the horizontal section, Item 72. The loading may also be accomplished as desired from the end of the cask subassembly, Figure 5.

Item 48 is a fabricated subassembly consisting of Items 48, 50, 52, 54 and 56. This subassembly is attached to the single vertical spar, Item 20, and to the horizontal section, Item 72. This assembly is also supported, as required, by the structure Item 76.

The fabricated subassembly consists of Items 48, 50, 52, 54 and 56. It is a multiple construction of stainless steel interliner--Item 48, a high hydrogen neutron shielding material--Item 50, a stainless steel section--Item 52, gamma shielded material--Item 54, and an outer steel assembly--Item 56. Figure 5 also has in the illustration a secondary cooling system illustrated with small circles of Item 62 and the controls illustrated in Item 70.

The over-the-road tractor methods of shipment utilizes a wheel assembly to be attached to the side structural supports, Item 18. It should be most carefully noted the Trudeau-Haagensen cask of Figures 5 and 6, as illustrated in Figures 3 and 4, does not utilize the conventional flatbed truck assembly.

Figure 5 also contains several other important items illustrated in the cross section of the cask. Item 26 side member is part of the structural

TRACTOR-TRAILER WITH CASK

FIG. 3

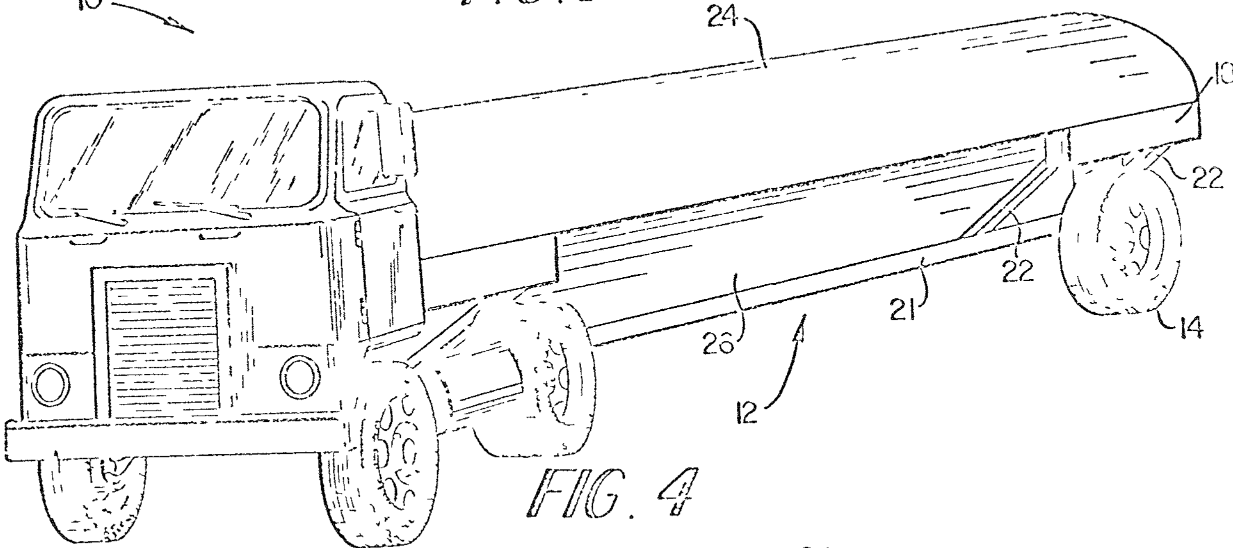
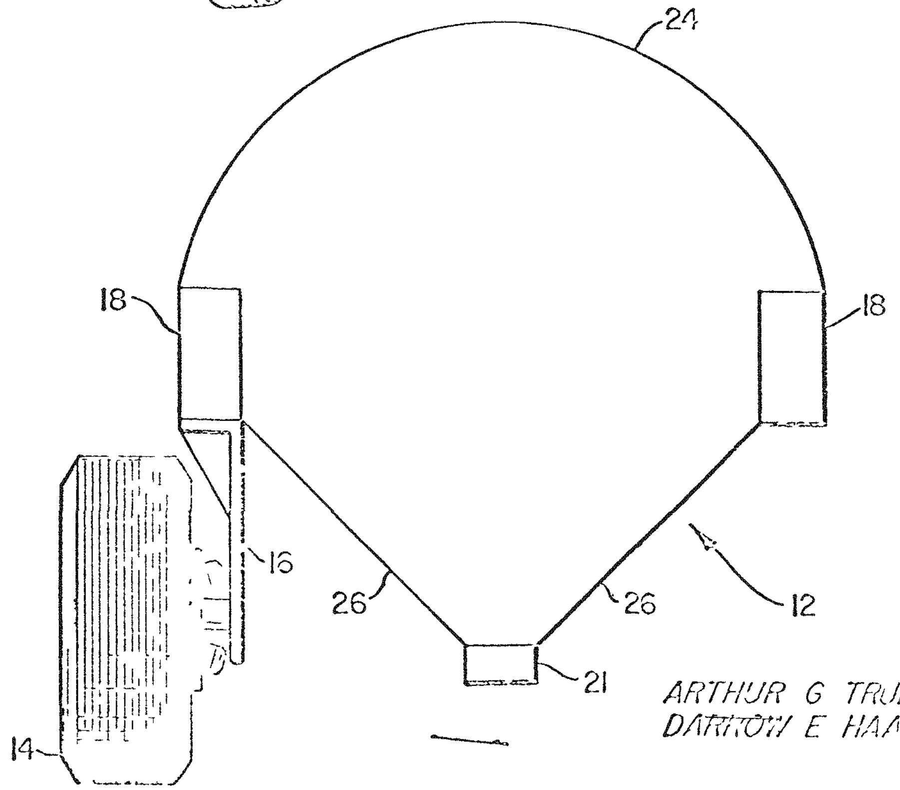


FIG. 4



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ATTORNEYS

FIG. 5

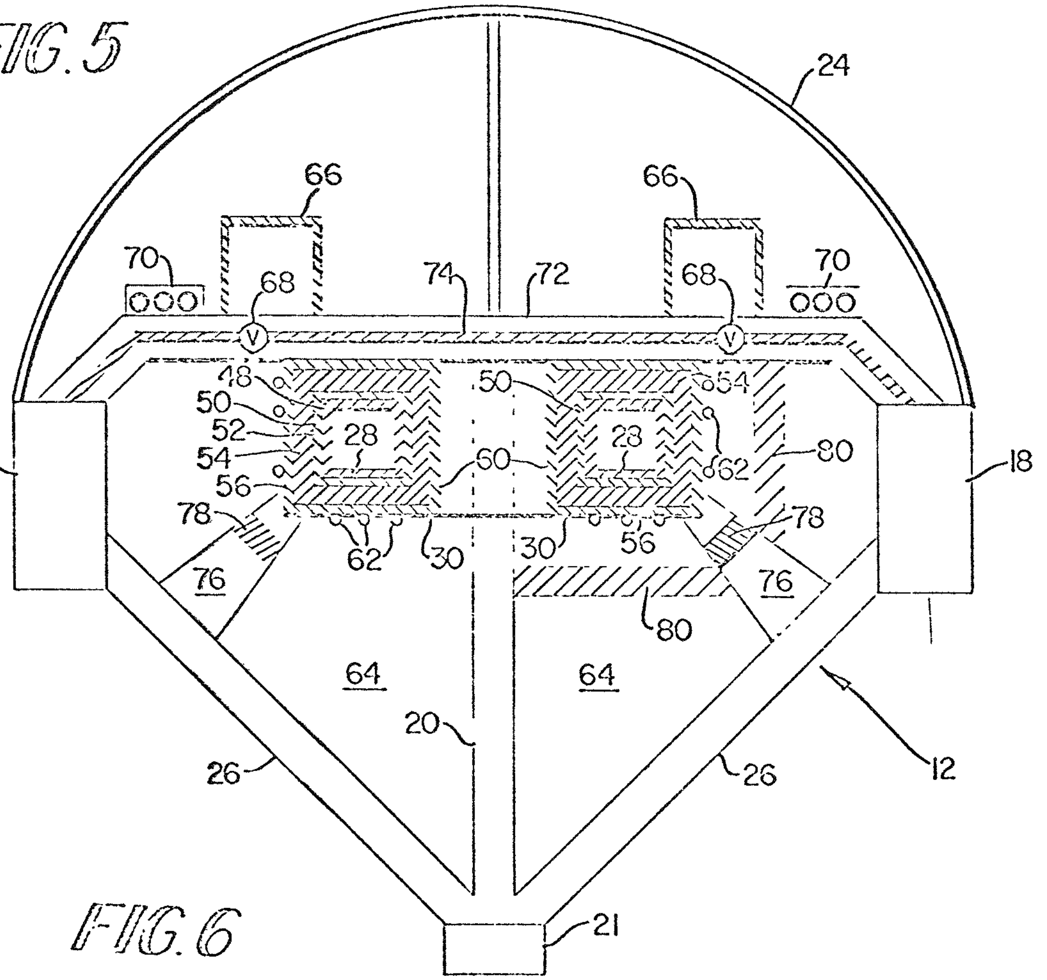
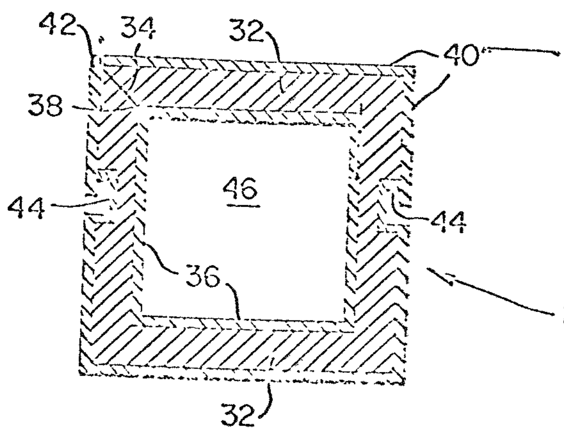


FIG. 6



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ERRATA

CONF-710801 (Vol. 1)

EXPERIENCE IN THE TRANSPORTATION OF RADIOACTIVE MATERIALS IN ITALY

by C. Faloci and A. Susanna

The caption for Table 2, page 349 should read

Table 2. Values of P_r, P'_r, Q_r and Q'_r for 1969 and 1970

Figure 1, page 352, and Figure 2, page 353 should be replaced with the following graphs:

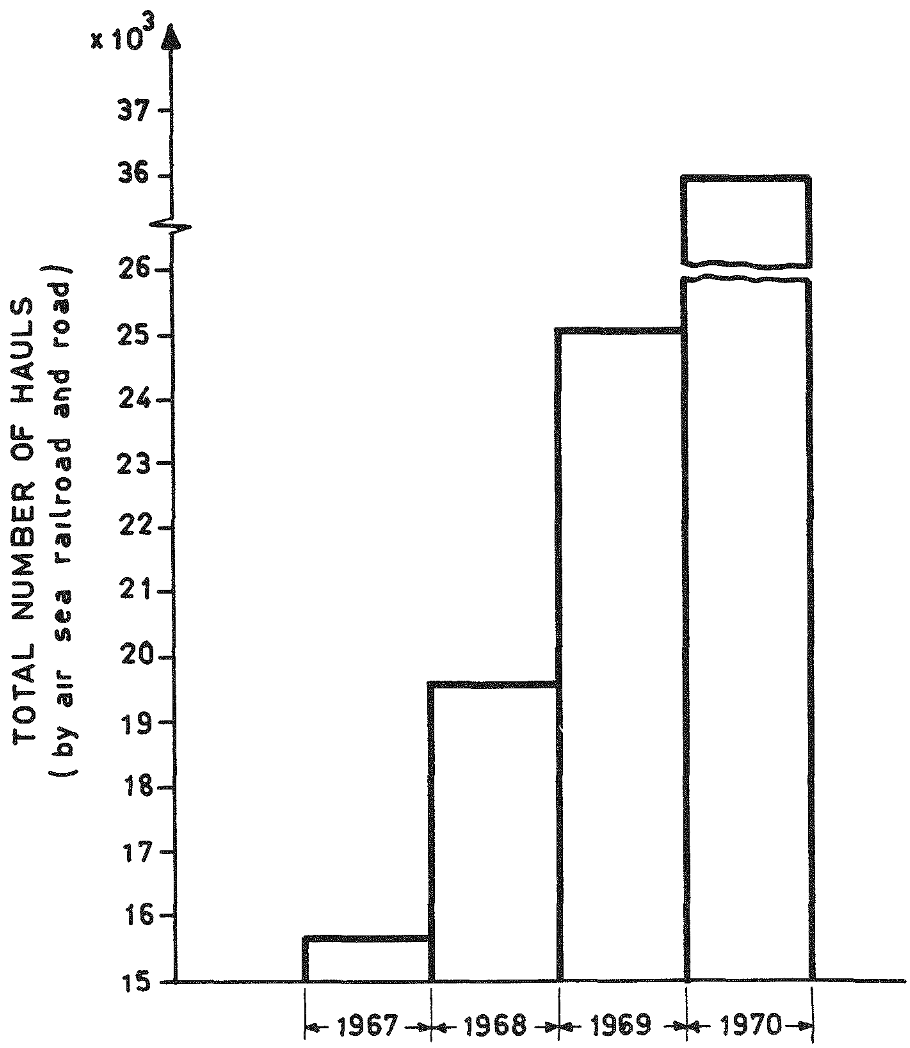


Fig. 1 - Total number of hauls of radioactive materials in Italy (by air, sea, railroad and road)

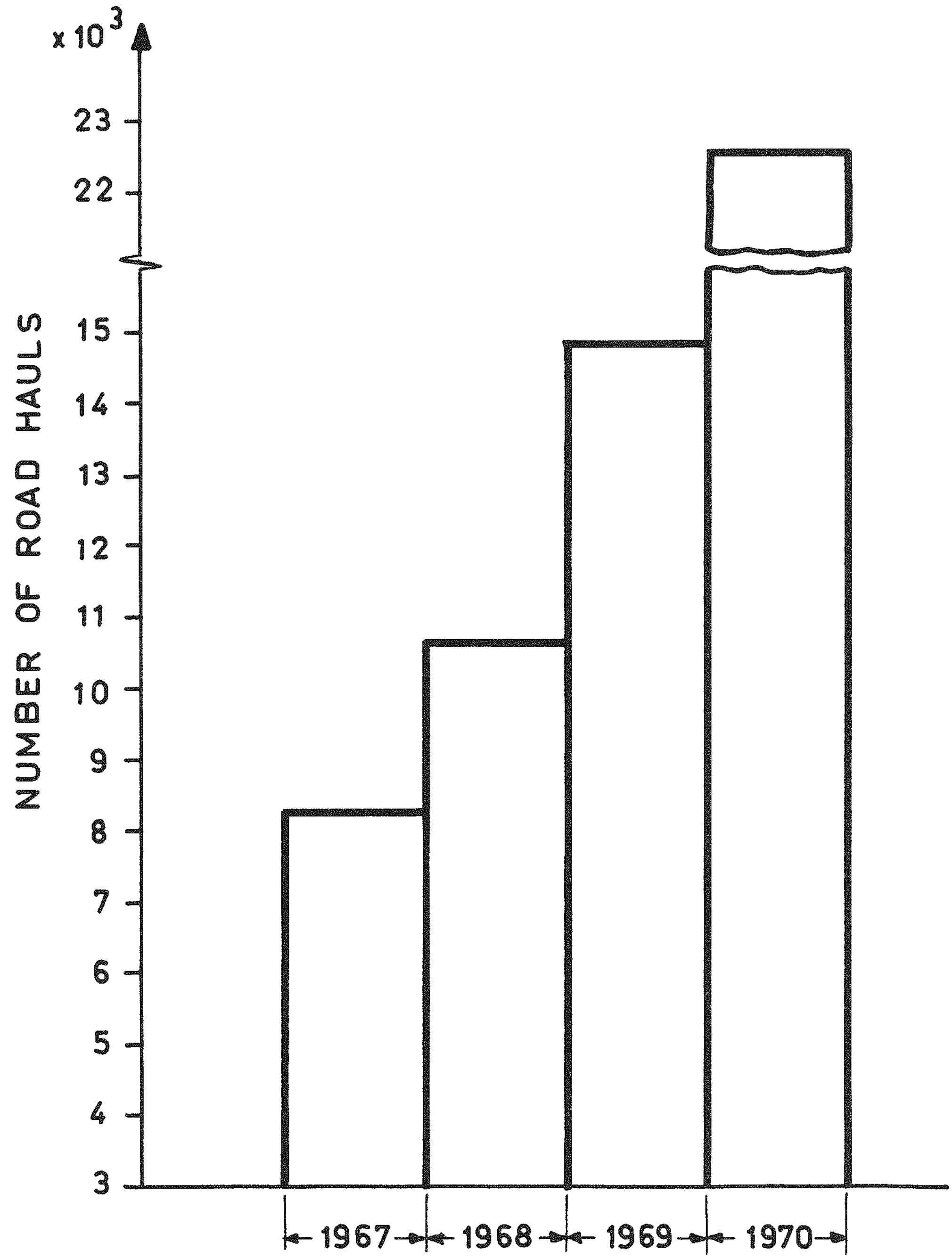


Fig. 2 - Number of road hauls of radioactive materials in Italy.

6

ERRATA

Conf-710801 (Vol. 1)

PROCESSING AND PACKAGING OF SOLID WASTES FROM BWR's

by H. L. Loy and D. C. Saxena

Data for Dresden II shown in Table 2, Radwaste Shipments, on page 485 should read as follows:

Date	Burial Ground	Total Activity	Volume
May, 1970	No Shipment	--	--
Aug., 1970	Sheffield, Ill.	580 mCi	2,920 ft^3
Sept., 1970	Sheffield, Ill.	3,560 mCi	2,670 ft^3
Oct., 1970	Sheffield, Ill.	900 mCi	2,100 ft^3
Nov., 1970	Sheffield, Ill.	2,900 mCi	4,450 ft^3
Dec., 1970	Sheffield, Ill.	1,610 mCi	1,020 ft^3

ERRATA

CONF-710801 (Vol. 2)

A METHOD OF CONTROLLING RADIATION EXPOSURES OF PERSONS IN AIRCRAFT DURING TRANSPORTATION OF RADIOACTIVE MATERIALS

by P. A. Lecomte

Additional documentation to paper, pages 564-591.

RADIOACTIVE TRAFFIC FACTOR

London Heathrow Airport

Slide #1

January to December 1970

1. Data from UK National Radiological Protection Board.

Amersham - consignments related to different flights ranges from 30 to 140 flights per day and estimate of an average of 90 flights per day over a 5 day week.

Harwell - estimate of an average of 10 flights per day over a 5 day week.

Total (estimated) flights with consignments from Amersham and Harwell to UK and overseas - 26,000 per year (100 per day for 5 day week and 52 weeks per year).

Total of above from LHR - 26,000 less, say 5% - 24,700

Total of all scheduled airline departures from LHR - 100,800 international departures and 22,400 domestic flights - 123,200.

$$RTF = \frac{24,700}{123,200} = 1 : 5$$

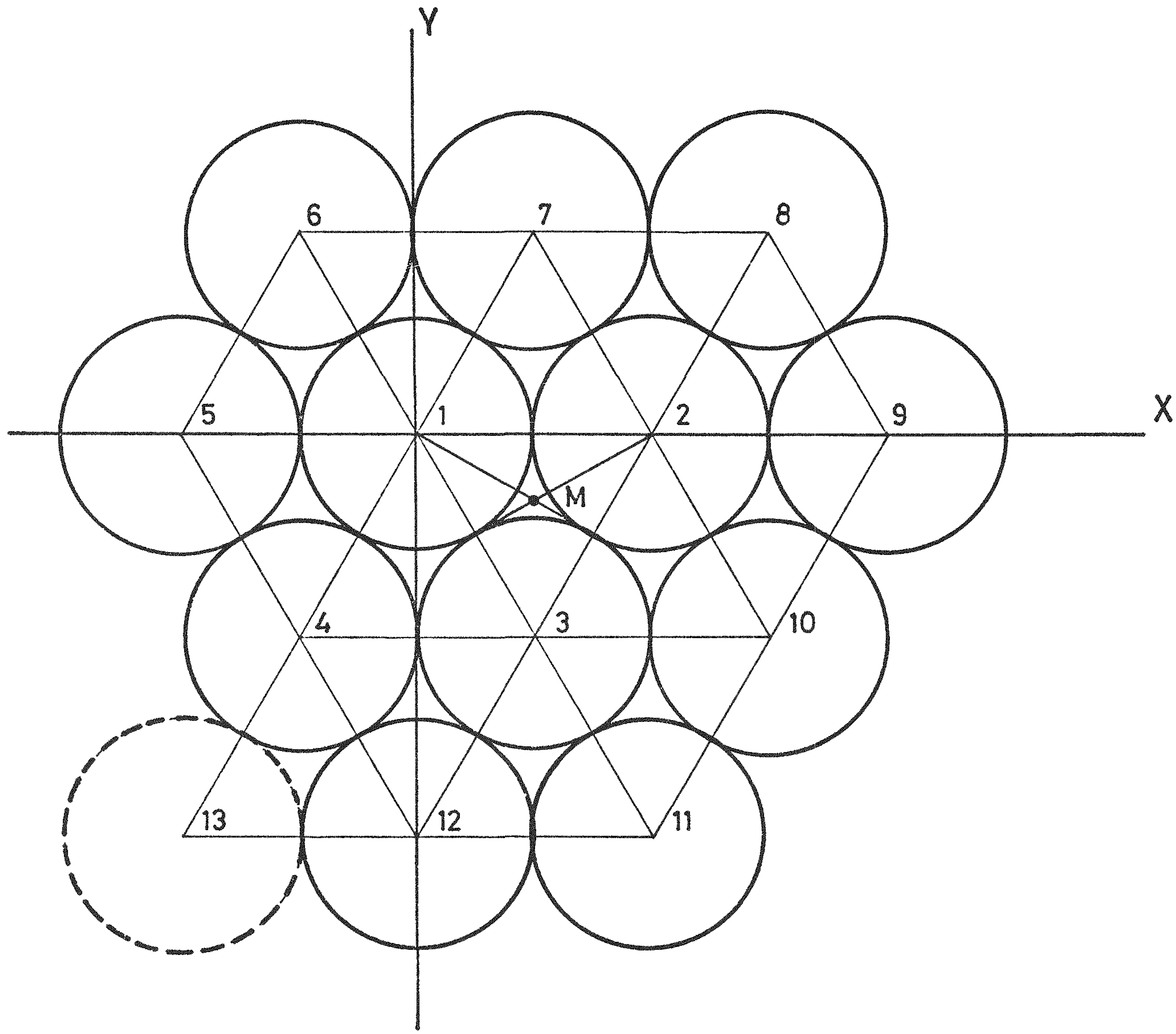
2. Data from British Overseas Airways Corporation.

4,000 consignments of radioactive materials were handled at LHR by BOAC in 1970. These were spread over about 3,200 different flights.

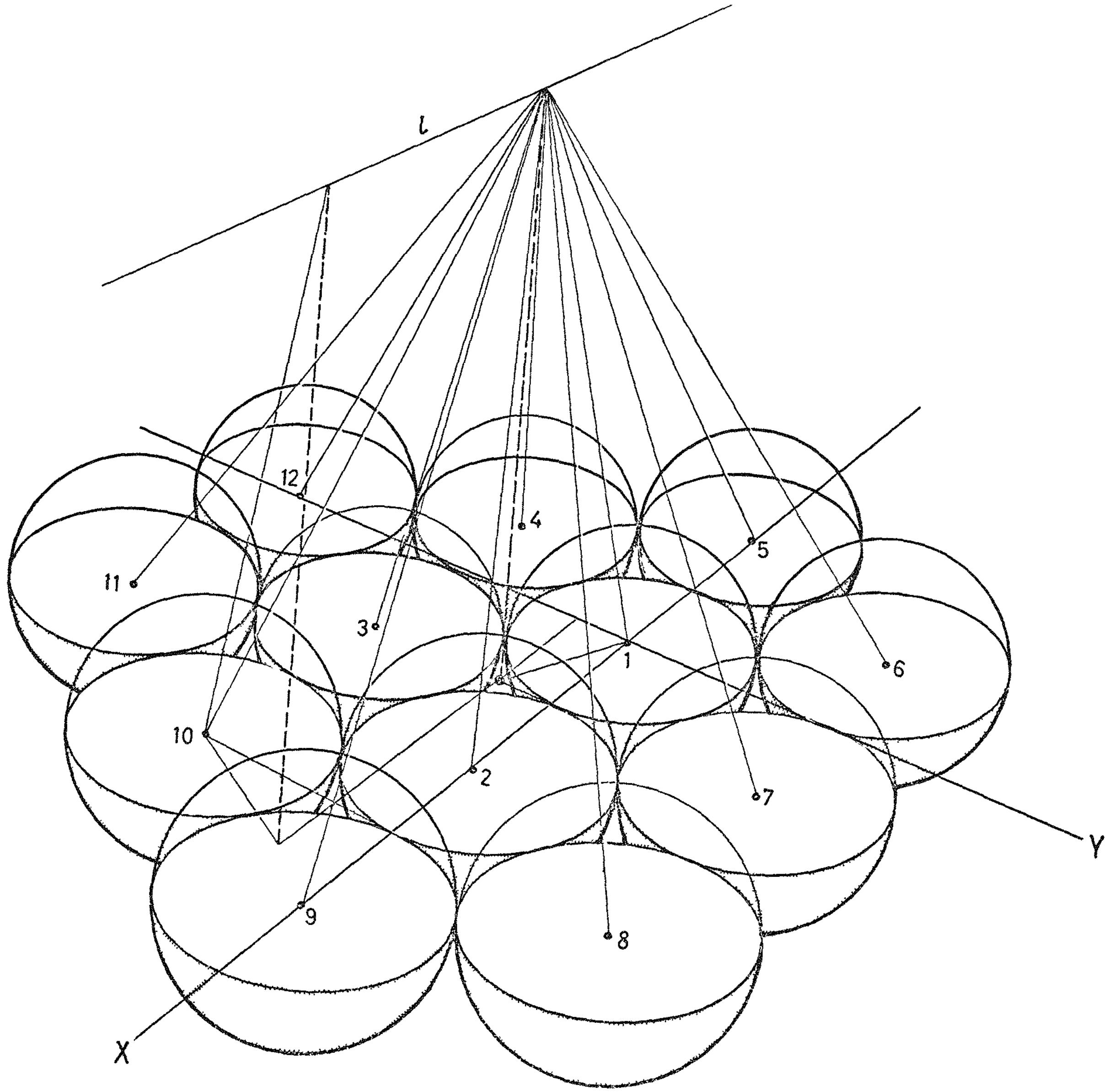
In the same period the actual number of outbound flights handled by BOAC, was about 13,000.

$$RTF = \frac{3,200}{13,000} = 1 : 4$$

Slide #4



Slide #5



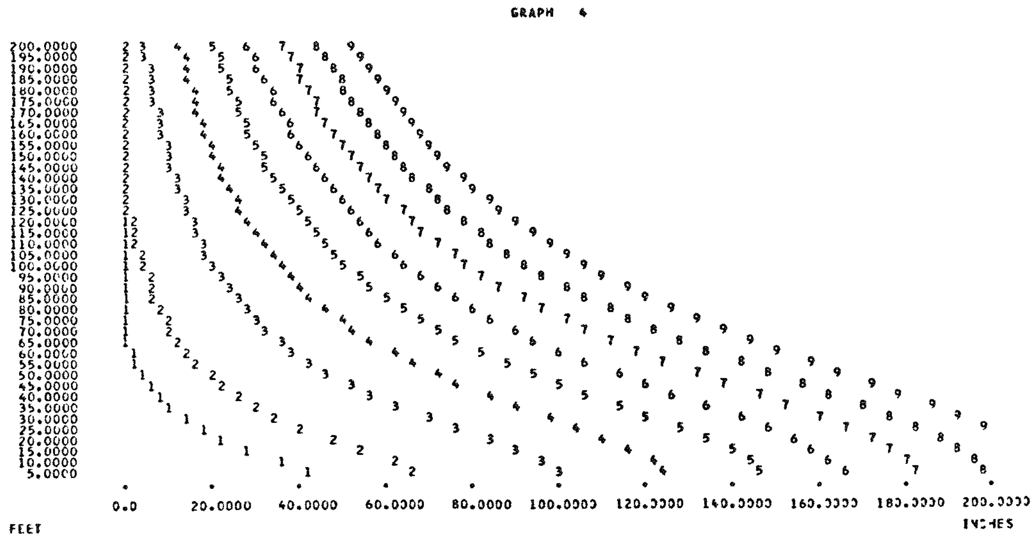
Slide #10

GRAPH 4 LISTING

Cabin Length, Feet	Total Sum of Transport Indexes: 5	10	20	30	40	50	60	70	80
	Segregation distance, inches								
5.0000	42.8400	67.0100	100.2100	*125.8500	*147.3000	*165.1500	*183.2500	*199.0500	
10.0000	36.6600	62.0700	96.6000	*122.7800	*144.6300	*163.7700	*181.0400	*197.0000	
15.0000	29.5300	55.3200	91.1200	*117.9900	*140.3900	*159.9400	*177.4900	*193.6700	
20.0000	23.2200	48.1500	84.4700	*111.9200	*134.8800	*154.8800	*172.7500	*189.2000	
25.0000	18.1500	41.4700	77.3600	105.1300	*128.4500	*148.8600	*167.0400	*183.7700	*199.1500
30.0000	14.1900	35.6400	70.3400	98.0700	*121.4700	*142.1700	*160.6000	*177.5900	*193.2300
35.0000	11.0700	30.6900	63.7500	91.0300	114.3600	*135.1200	*153.7000	*170.8600	*186.7200
40.0000	8.5800	26.5400	57.7600	84.2700	107.3500	*127.9400	*146.5400	*163.8000	*179.8100
45.0000	6.5700	23.0400	52.4000	77.9500	100.5700	120.8900	139.3600	*156.6000	*172.6800
50.0000	4.9100	20.0800	47.6400	72.1300	94.1400	114.1300	132.4600	*149.4200	*165.4800
55.0000	3.5200	17.5500	43.4400	66.8200	88.1200	107.6800	125.7400	142.5300	*158.3300
60.0000	2.3400	15.3800	39.7200	62.0100	82.5500	101.5800	119.3000	135.8700	151.4400
65.0000	1.3300	13.5000	36.4200	57.6500	77.4100	95.8700	113.1800	129.4700	144.8500
70.0000	0.4600	11.8500	33.4800	53.7100	72.6900	90.5600	107.4100	123.3700	138.5000
75.0000	0.0	10.4100	30.8600	50.1500	68.3700	85.6200	102.0000	117.5800	132.4200
80.0000	0.0	9.1200	28.5100	46.9100	64.4000	81.0500	96.9400	112.1200	126.6500
85.0000	0.0	7.9800	26.3900	43.9600	60.7600	76.8200	92.2200	106.9900	121.1300
90.0000	0.0	6.9500	24.4800	41.2600	57.4100	72.9100	87.8200	102.1700	116.0100
95.0000	0.0	6.0300	22.7400	38.8300	54.3300	69.2900	83.7200	97.6600	111.1300
100.0000	0.0	5.1900	21.1600	36.5800	51.5000	65.9200	79.8900	93.4300	106.5500
105.0000	0.0	4.4300	19.7100	34.5100	48.8700	62.8100	76.3300	89.4600	102.2300
110.0000	0.0	3.7300	18.3800	32.6100	46.4500	59.9100	73.0000	85.7500	98.1700
115.0000	0.0	3.1000	17.1600	30.8500	44.2000	57.2100	69.8900	82.2700	94.3400
120.0000	0.0	2.5100	16.0300	29.2200	42.1100	54.6900	66.9800	79.0000	90.7400
125.0000	0.0	1.9700	14.9800	27.7100	40.1600	52.3400	64.2600	75.9300	87.3500
130.0000	0.0	1.4700	14.0100	26.3000	38.3400	50.1400	61.7000	73.0400	84.1600
135.0000	0.0	1.0000	13.1100	24.9900	36.6400	48.0800	59.3000	70.3200	81.1400
140.0000	0.0	0.5700	12.2700	23.7600	35.0500	46.1400	57.0500	67.7600	78.2900
145.0000	0.0	0.1700	11.4800	22.6100	33.5600	44.3300	54.9200	65.3400	75.6000
150.0000	0.0	0.0	10.7500	21.5300	32.1500	42.6100	52.9100	63.0600	73.0500
155.0000	0.0	0.0	10.0500	20.5200	30.8300	41.0000	51.0200	60.9000	70.6400
160.0000	0.0	0.0	9.4000	19.5700	29.5900	39.4800	49.2300	58.8600	68.3500
165.0000	0.0	0.0	8.7900	18.6700	28.4100	38.0400	47.5400	56.9200	66.1800
170.0000	0.0	0.0	8.2100	17.8200	27.3000	36.6700	45.9300	55.0800	64.1200
175.0000	0.0	0.0	7.6700	17.0100	26.2500	35.3800	44.4100	53.3300	62.1600
180.0000	0.0	0.0	7.1500	16.2500	25.2500	34.1500	42.9600	51.6700	60.2900
185.0000	0.0	0.0	6.6600	15.5300	24.3000	32.9900	41.5800	50.0900	58.5200
190.0000	0.0	0.0	6.2000	14.8400	23.4000	31.8800	40.2700	48.5800	56.8200
195.0000	0.0	0.0	5.7600	14.1900	22.5400	30.8200	39.0200	47.1500	55.2000
200.0000	0.0	0.0	5.3400	13.5700	21.7300	29.8100	37.8300	45.7700	53.6500

* denotes compact arrangement of packages.

Slide #11

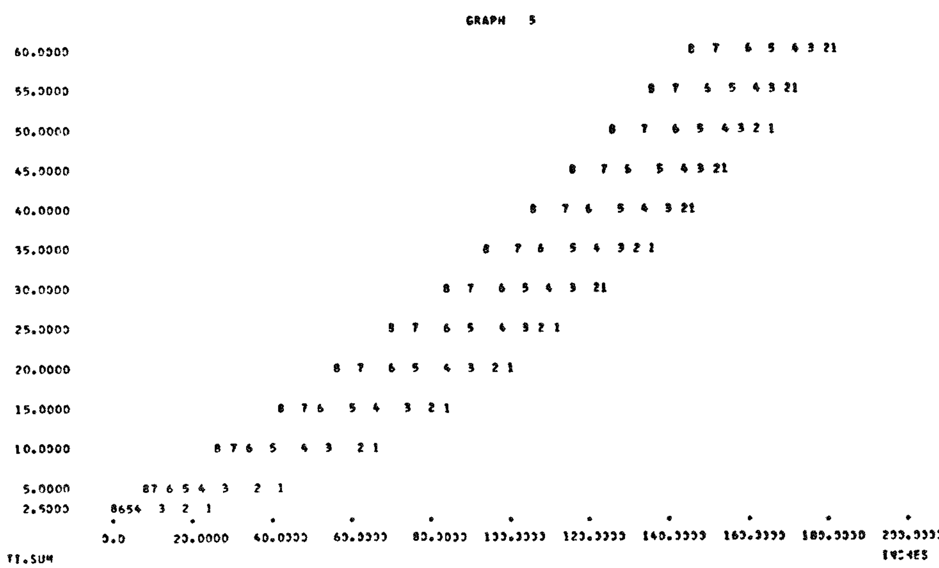


SEGR.DIST. VERSUS CAB.LENGTH FOR SUM OF TI. CONSTANT   MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR SUM OF TI. = 5.000
2 CURVE IS FOR SUM OF TI. = 10.000
3 CURVE IS FOR SUM OF TI. = 20.000
4 CURVE IS FOR SUM OF TI. = 30.000
5 CURVE IS FOR SUM OF TI. = 40.000
6 CURVE IS FOR SUM OF TI. = 50.000
7 CURVE IS FOR SUM OF TI. = 60.000
8 CURVE IS FOR SUM OF TI. = 70.000
9 CURVE IS FOR SUM OF TI. = 80.000

Slide #12

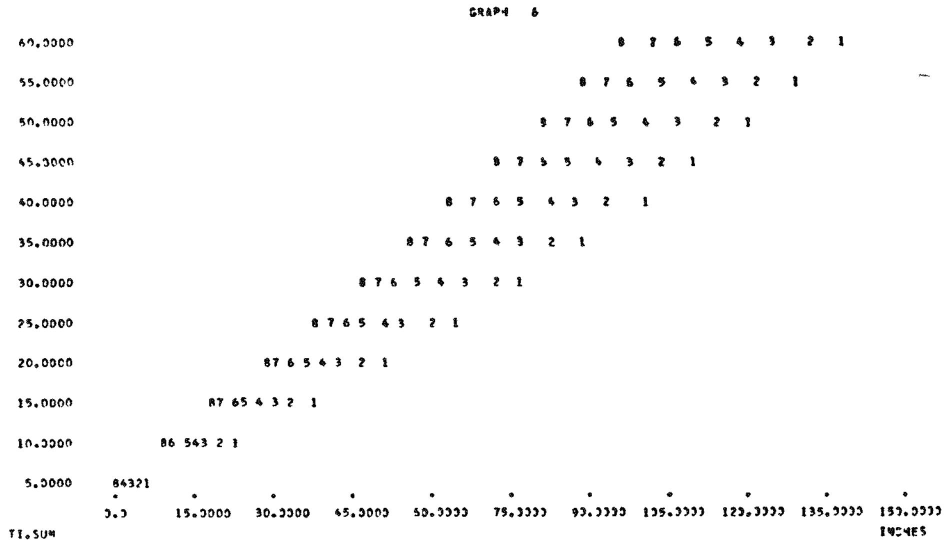


SEGR.DIST. VERSUS SUM OF TI. FOR CAB.LENGTH CONSTANT   MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR CAB.LENGTH = 5.000
2 CURVE IS FOR CAB.LENGTH = 10.000
3 CURVE IS FOR CAB.LENGTH = 15.000
4 CURVE IS FOR CAB.LENGTH = 20.000
5 CURVE IS FOR CAB.LENGTH = 25.000
6 CURVE IS FOR CAB.LENGTH = 30.000
7 CURVE IS FOR CAB.LENGTH = 35.000
8 CURVE IS FOR CAB.LENGTH = 40.000

Slide #13

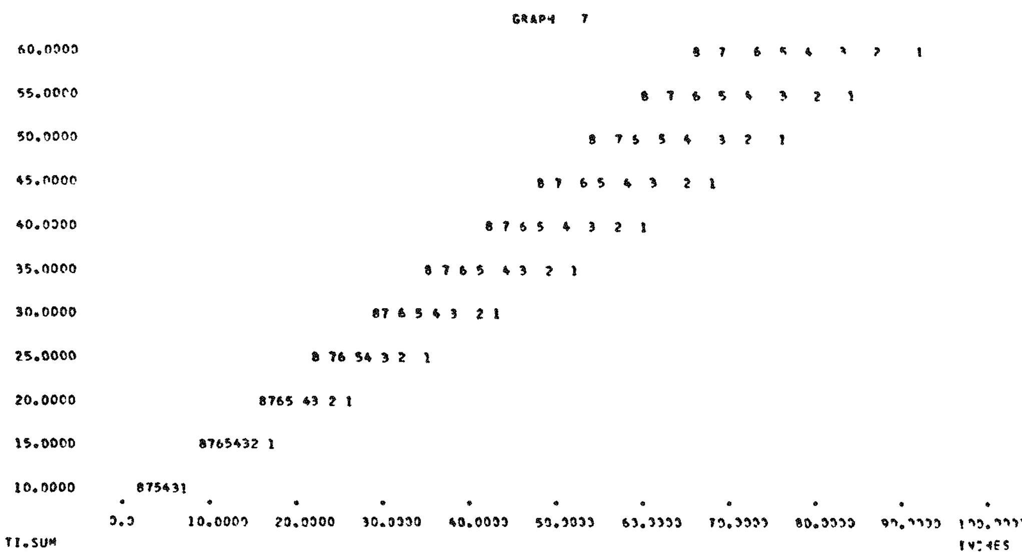


SEGR.DIST. VERSUS SUM OF TI. FOR CAB.LENGTH CONSTANT   MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR CAB.LENGTH = 45.000
2 CURVE IS FOR CAB.LENGTH = 50.000
3 CURVE IS FOR CAB.LENGTH = 55.000
4 CURVE IS FOR CAB.LENGTH = 60.000
5 CURVE IS FOR CAB.LENGTH = 65.000
6 CURVE IS FOR CAB.LENGTH = 70.000
7 CURVE IS FOR CAB.LENGTH = 75.000
8 CURVE IS FOR CAB.LENGTH = 80.000

Slide #14

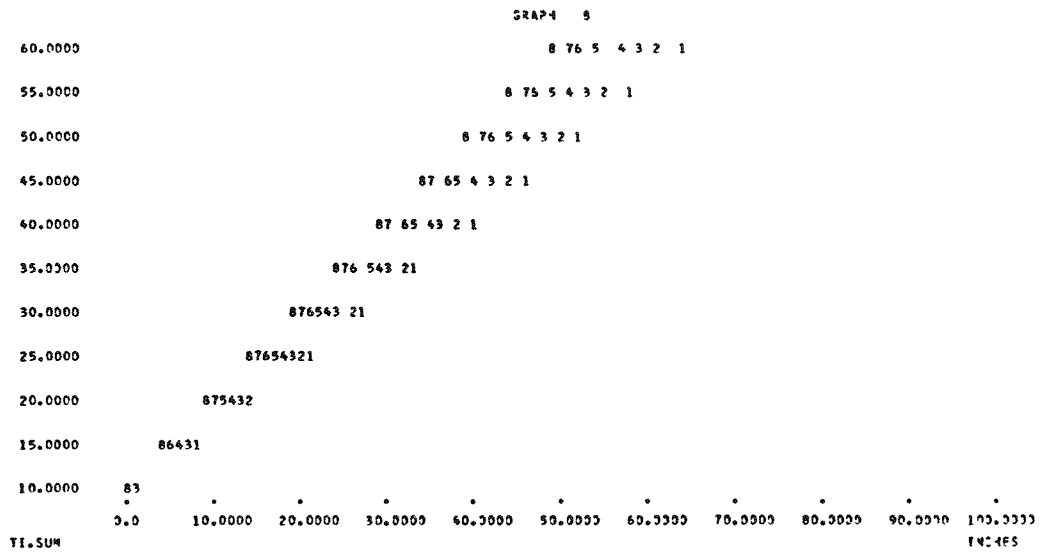


SEGR.DIST. VERSUS SUM OF TI. FOR CAB.LENGTH CONSTANT   MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR CAB.LENGTH = 85.000
2 CURVE IS FOR CAB.LENGTH = 90.000
3 CURVE IS FOR CAB.LENGTH = 95.000
4 CURVE IS FOR CAB.LENGTH = 100.000
5 CURVE IS FOR CAB.LENGTH = 105.000
6 CURVE IS FOR CAB.LENGTH = 110.000
7 CURVE IS FOR CAB.LENGTH = 115.000
8 CURVE IS FOR CAB.LENGTH = 120.000

Slide #15

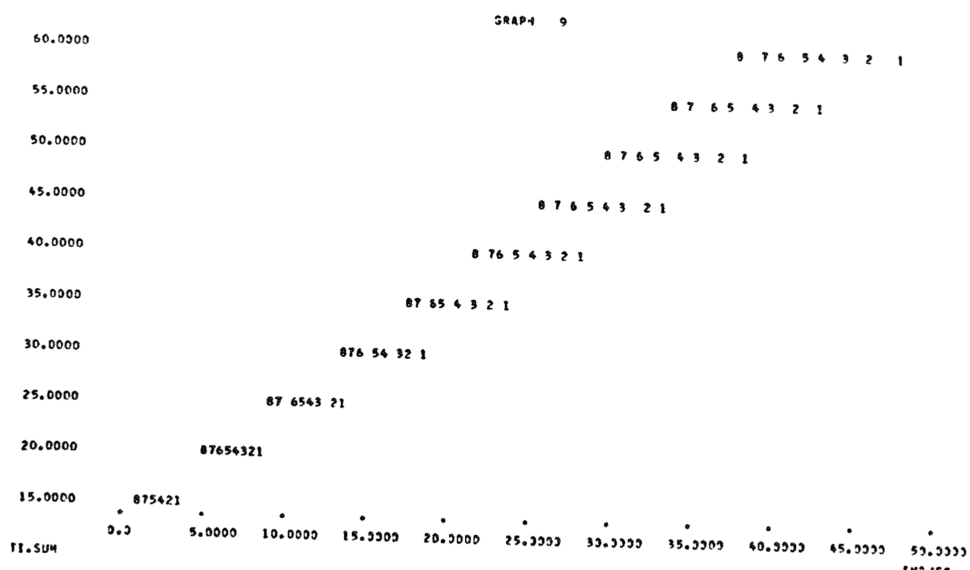


SEGR.DIST. VERSUS SUM OF TI. FOR CAB.LENGTH CONSTANT MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR CAB.LENGTH = 125.000
2 CURVE IS FOR CAB.LENGTH = 130.000
3 CURVE IS FOR CAB.LENGTH = 135.000
4 CURVE IS FOR CAB.LENGTH = 140.000
5 CURVE IS FOR CAB.LENGTH = 145.000
6 CURVE IS FOR CAB.LENGTH = 150.000
7 CURVE IS FOR CAB.LENGTH = 155.000
8 CURVE IS FOR CAB.LENGTH = 160.000

Slide #16

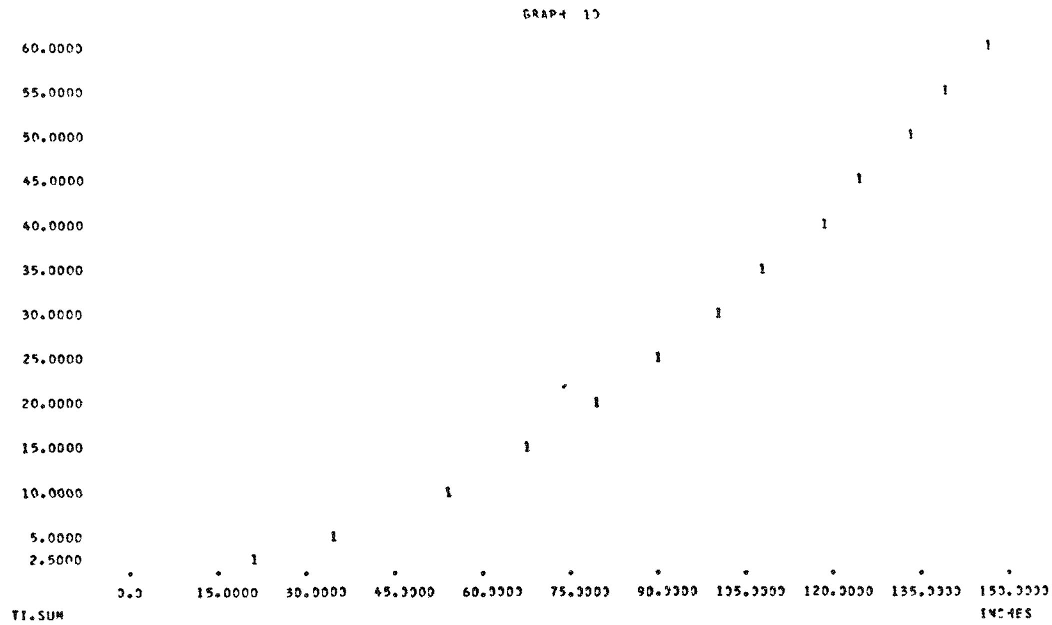


SEGR.DIST. VERSUS SUM OF TI. FOR CAB.LENGTH CONSTANT MEAN DOSE = 4.000

PACKAGES OF 0.288 METRE RADIUS

1 CURVE IS FOR CAB.LENGTH = 165.000
2 CURVE IS FOR CAB.LENGTH = 170.000
3 CURVE IS FOR CAB.LENGTH = 175.000
4 CURVE IS FOR CAB.LENGTH = 180.000
5 CURVE IS FOR CAB.LENGTH = 185.000
6 CURVE IS FOR CAB.LENGTH = 190.000
7 CURVE IS FOR CAB.LENGTH = 195.000
8 CURVE IS FOR CAB.LENGTH = 200.000

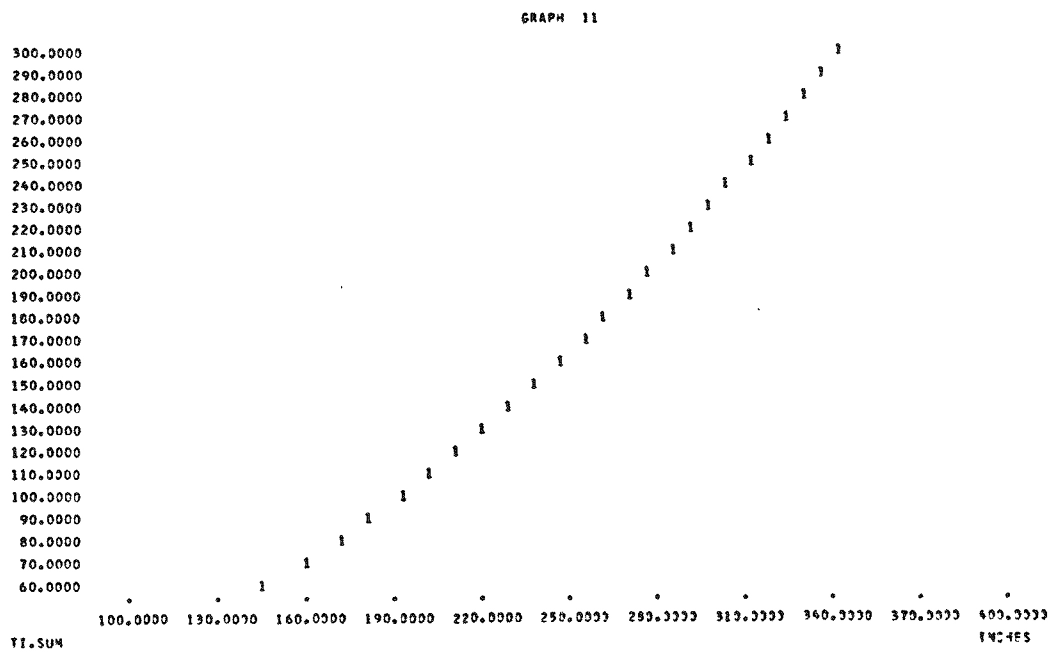
Slide #17



SEGR.DIST. VERSUS SUM OF TI. FOR PAC.RADIUS CONSTANT MEAN DOSE = 6.000

FLIGHT DECK NORMAL CONDITION
1 CURVE IS FOR PAC.RADIUS = 0.288

Slide #18



SEGR.DIST. VERSUS SUM OF TI. FOR PAC.RADIUS CONSTANT MEAN DOSE = 6.000

FLIGHT DECK FULL LOAD CONDITION
1 CURVE IS FOR PAC.RADIUS = 0.288

ERRATA

CONF-710801 (Vol. 2)

CRITICALITY SAFETY EVALUATIONS OF SHIPPING CONTAINERS USED BY IDAHO NUCLEAR CORPORATION AT NRTS

by J. K. Fox and W. G. Morrison

The calculations listed in this report (page 803) on casks made of lead indicated that lead is inferior to water as a reflector. This result did not seem unreasonable until receipt of the June 1971 issue of Nuclear Science and Engineering. This contains a report by Klotzkin, et al. on experiments at Bettis that show lead to be appreciably better than water as a reflector. Their system (HTFF Core) has a high leakage (small core) and a somewhat hardened spectrum. However, some of our cases were similar. We still do not have ENDF/B cross sections for lead available. Cross sections based on GAM-II recently were obtained from ORNL for use with KENO. When these were used for the National Lead Casks, the results showed that the lead-water mixture gives k_{eff} values 3 to 4 percent higher than a pure water reflector. The width of water gap between the fuel and lead obviously affect the delta K due to the lead. Further studies should be made on the effects of spectrum, system leakage fraction, and water gap on the increase of k_{eff} due to a lead reflector.

THIRD INTERNATIONAL SYMPOSIUM
ON THE PACKAGING AND TRANSPORTATION
OF RADIOACTIVE MATERIALS

August 16-20, 1971 Richland, Washington, USA

THE HIJACKING AND PILFERAGE PROBLEM

PANEL MODERATOR: Mr. William A. Brobst
Chief of Transportation
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Mr. Chester H. Smith
Select Senate Committee on Small Business
United States Senate
Washington, D.C.

Mr. Daniel A. Ward
Acting Deputy Director
Office of Transportation Security
U.S. Dept. of Transportation
Washington, D.C.

THE HIJACKING AND PILFERAGE PROBLEM

Mr. Brobst:

Nuclear transportation specialists may not have too much occasion to work every day with the problems of theft in transportation, so this panel is ready to bring to you, in the form of a round table discussion, a very free and open discussion of some of the reasons why we are becoming so concerned about theft in transportation and the impact of this concern on the nuclear industry.

You are probably all reasonably familiar with the recent Congressional hearings on theft in transportation. Congress studied the infiltration of the transportation industry by the crime syndicates, particularly the Mafia. They looked at both casual and organized theft of across-the-dock freight, and they looked at vehicle hijackings.

We learned of the disturbing presence of many secret and top secret documents in what has turned out to be a very hostile environment indeed. General Delmar Crowson, Director of Safeguards for the AEC, recently said that there have been no known cases of hijacking or theft of special nuclear materials in the transport cycle. So far we have been very fortunate in this industry - the only special nuclear materials that have been involved in this type of thing in the past suffered only an accidental misrouting, and we have always managed to recover it soon after it strayed. Our experience has been good. Why do we worry? We worry because the growth of nuclear power involves a hundredfold or perhaps a thousandfold increase in the number of shipments of special nuclear materials. For this reason, we think it is no longer a matter of "if", but "when" a shipment of special nuclear materials will disappear enroute. For this reason we must do everything we can, within reason, to reduce the probability of this happening. But we must recognize that the probability will never be zero.

There are four basic facets in safeguard that we will be talking about tonight. The first is the prevention of material from being stolen. This is the most important of all. But no matter how far we go in trying to prevent material from being stolen, the probability will not be zero and we must also have plans for what we do when it is stolen. The second facet, then, is detection - the knowledge that it has been stolen. The third is the location of this material - to try to find out when it was stolen, where it was stolen, what is where, and who has it. The fourth, then, is the recovery of the material.

With these shipments moving through the extremely hostile environment of transportation, we have only three things that we can really do. One is to try and change that environment. The second is to adjust to the environment. The third is to remove our materials from the environment. We think there is very little that we, in the AEC, can do to change the environment - we just have no jurisdiction in the criminal field. The Department of Justice, the Department of Transportation, the Interstate Commerce Commission - the various agencies involved already have their hands full and there is probably little the AEC can add in that area.

Then we are left either with adjusting to that environment or removing our materials from it. We can adjust by perhaps escorting every single shipment of special nuclear materials - guards. They do this in Russia. Everything is convoyed. Well, what if somebody came with a bigger army? We can remove things from across-the-dock freight theft situations by shipping them nonstop in exclusive-use vehicles from point-to-point. This won't reduce the probability to zero, but it will eliminate it from that one very significant sector. We could set up our own transportation system and remove things from the environment - put it on AEC-owned aircraft, AEC-couriered - military aircraft. That's fine for AEC materials, but what help is that for the industry? Before long, industry will be shipping much more of these types of materials than we do. So we have to come up with some sort of solution that can be used by the private nuclear industry, as well as the AEC.

We set up this panel to discuss this problem so that you might understand what we, in the government and in the industry, are facing in trying to solve the problem. At this point, I'd like to turn the meeting over to the panel - these are the fellows who are the real experts.

I'd like Chester Smith to start off and tell us what Congress is doing.

Mr. Smith:

It is a distinct pleasure to appear at this distinguished International Symposium, devoted to a subject so vital to our society - its calm title almost belies the overwhelming importance of its real goal - the safe and swift transport of radioactive materials through normal channels of commerce, or otherwise. As a panel substitute tonight for Senator Alan Bible of Nevada, Chairman of the Senate Small Business Committee, I can say that his interest in this week-long conference is many sided; because he also serves as a member of the Joint Congressional Committee on Atomic Energy and as a Senior Member of the Senate Appropriations Committee, with funding responsibility over the Atomic Energy Commission. Two years ago the SSBC, in assessing the impact of crime against this country's 5-1/2 million small businesses, began investigatory hearings into the theft, pilferage, and hijacking of cargo from air, truck, ship and rail carriers, as the only Congressional Committee then examining into this increasingly critical crime area. This year, Congressional interest has quickened - with two other Senate Committees opening investigations into the inroads of organized crime into commerce. To capsule the problem as we see it, let me quote a statement Senator Bible made before the June 18th Session of the National Conference on the Cargo Security Crisis in Washington, D.C., and I quote.

"After two years of listening to testimony from government, transportation, and regulatory agencies, carriers, insurers, shippers, and consumers, one fact comes through loud and clear - the cargo carrier crime crisis is growing alarmingly day by day. Our law enforcement agencies, our shipping regulatory bodies, government, and the carrier industry have been unable to mount an effective response. Today, theft of cargo represents the biggest multibillion dollar racket nationally. The carrier cargo crisis is here today; whether we care to admit it or not. Today, in this world of swift, turbulent change, we learn to live with extremes;

but today, cargo carriers are plagued with losses never thought possible a few short years ago. And what kind of dollar losses are we talking about? Our Committee staff, together with experts from the Congressional Library's Research Service, estimates that in 1970 truck thefts and hijacking reached 900 million dollars. Airlines were 110 million and probably a good deal more. Railroad losses climbed to around 250 million, possibly 50% or more greater than in 1969, and maritime shipping reached 210 million. Some insurance people say these totals should be much higher. How do we measure the scope and extent of this problem - a nationwide racket that cost American shippers, conservatively, last year 1 billion 470 million dollars in losses (a 17 to 23% increase over 1969). The answer is - an accurate measurement is next to impossible, because no governmental agency and no private trade or service organization keeps records of theft losses, total tonnage, or value of cargo shipped in this country. We believe this will be changing. After prodding by the SSBC, the ICC ordered, effective October 1, that all Class I motor truck and contract carriers, representing 75% of all ICC regulated inter-city tonnage, will begin compiling uniform loss reports. The Civil Aeronautics Board has a comparable rule-making proceedings in progress for air carriers, but presently the airline industry is dragging it's "let's not do it until we have to" feet. The Federal Maritime Commission is making progress toward the reporting goal. There seems little doubt that the country's transport industry has become the favorite target for organized and unorganized crime. The pickings are richer and easier. Cargoes have overwhelmed facilities. Security efforts provide little security. And that old crutch of substituting insurance payments for good security has almost imperiled the insurance industry.

One insurance company, which reported only two bankruptcies of motor carriers in 30 years, recently revealed that 5 trucking firms went broke in 1970 alone. And one insurance executive said insurance protection can be made readily available only in a society that obeys the law. Another insurance executive told our Committee and I quote, "... many of these things are stolen for order and they are handled by organized crime. The markets are already established, and the property is absorbed into our economic system just like a huge dry sponge - it just sucks it all up and it disappears. We do not penetrate the activities of the receivers, the fences and the people in possession of this stolen property."

Certainly, those of you with responsibilities for the safe and expeditious shipment of radioactive materials in increasing quantities must feel like a lone infantryman lost in a mine field; not knowing where, what, or when the dangers are greatest. Obviously, the Atomic Energy Commission is primarily concerned that weapons do not fall into the wrong hands; and that radioactive materials shipped by it are safely delivered to the intended recipient. But the dangerous commodity and the natural catastrophe potential which you must consider make your roles critically important. The SSBC, of which I have the honor to be Staff Director and General Counsel - in official reports to the U.S. Senate has identified six contributing factors to the cargo theft problem, and barriers to the development of effective solutions as:

1. Lack of uniform loss data.
2. Lack of interest in, or knowledge of, basic physical security practices by carrier management.
3. Lack of interest on the part of governmental regulatory agencies about cargo theft as a result of inadequate liability limits and embargo practices and insufficient claims rules and procedures.
4. Lack of private-sector initiative to improve security, probably most pronounced in the air and maritime carrier areas.
5. Inadequate coordination among law enforcement agencies and between such agencies in the private section, and
6. Failure of federal departments and agencies to identify and mount an effective response to that problem.

Today, skyrocketing increases in cargo thefts are putting the whole carrier industry through an overdue and agonizing reappraisal of its entire operation. With the Congress becoming increasingly concerned, the conclusions that this Symposium and/or its attendees may reach - to promote safeguards in transportation of nuclear materials - should be beneficial to this broad-scale effort to bring law and order to the cargo transport system once again.

In conclusion, just remember that the first cargo-anti-crime manifesto was handed down from on high when God gave Moses the Ten Commandments; the eighth one reading, "Thou shalt not steal."

Mr. Brobst:

Thank you, Chet. Dan Ward, what's going on in DOT?

Mr. Ward:

There's been a lot of activity in Washington this summer, particularly on the cargo theft and pilferage problem. June 17 was a turning point, insofar as the Federal Government is concerned, in an all-out-effort to eliminate crime in the nation's transportation system. This didn't happen by spontaneous combustion. It resulted from a lot of effort, prodding and encouragement from a few national leaders, such as Chet Smith's boss, Senator Alan Bible from Nevada; and from Warren Magnuson, the Senator from the State of Washington. It was on June 17 that Secretary Volpe announced that the Transportation Department was taking on new initiative to organize a comprehensive government-industry effort to combat crime in transportation. General Benjamin Davis, who addressed this Symposium earlier this week, was moved to the No. 1 leadership spot as the Assistant Secretary for Transportation for Safety and Consumer Affairs. A new office of Transportation Security was established which reports directly to General Davis. I am the Deputy Director of this new office. This new office, by the way, absorbed the former office of Civil Aviation Security and its antiair-hijacking program--better known for its sky marshalls. This program was previously headed by General Davis. The other functions of the new office can be lumped together into a simple term called cargo security. Easy to say, but it is an extremely complex national problem with many government agencies involved that have closely related, and sometimes overlapping, responsibilities and interests.

For this reason Secretary Volpe, on June 17, also announced the sponsorship by DOT of a new interagency committee whose charter is to sort out the many programs and responsibilities of the federal agencies; and to seek adjustments which will produce the best overall effort. General Davis chairs this new interagency committee which includes policy level people--the top people in government--from the Departments of Commerce, Treasury, Defense, Justice, State and Labor, and three regulatory agencies, the ICC, FMC, and CAB. The Small Business and General Services Administration are members, along with the Postal Service. I was explaining some of this to Bill Brobst a couple of weeks ago and he immediately asked, "Why isn't AEC on this interagency committee?" Well, quite frankly, at the time that the interagency committee was being formed, those of us who had a hand in it were simply not aware of the AEC's problem in the protection of nuclear materials in transit. Now that sets me up just dandy here on this panel of experts, but I can say that the AEC has since been invited to join the interagency committee and I have done some homework on the AEC. I obviously am not caught up on the many years that have preceded this Symposium, but I do have some thoughts which may contribute to a useful discussion on the problems of protecting nuclear materials in the transportation system.

First, the combined actions of the Federal Government and industry - even if they were tremendously successful - would only bring about a reduction in cargo theft. Cargo theft is simply not going to be eliminated in its entirety - it's not going down to zero as you mentioned, Bill. As I understand the problem, the stakes are simply too high to lose even one small box of nuclear material to a thief, whether these materials are taken intentionally or whether they are taken accidentally. Therefore, special safeguards must be continued and expanded to assure that not one box of materials is lost or stolen as the private sector continuously increases the amount of materials requiring transportation from one part of the country to the other.

My second point relates to the analysis of the problem. Are the reasons for providing such safeguards actually realistic? The discussion of threat-agent motivation in the excellent summary of issues presented by the Institute of Nuclear Management last year will raise the hair on the back of your neck. Now, even if that particular assessment were only about 10% credible, its enough to convince me that positive accountability and special security precautions are mandatory in the shipment of nuclear materials. I would like to re-enforce this point of view by referring to experience gained from our Civil Aviation Security program. Bomb threats, and I'm referring now to conventional explosives, are a very serious problem to the airlines. They are increasing at an alarming rate, roughly 50% each year. (I won't go into numbers here.) I'm leading up to two points which are, as I see it, directly related to the problem of safeguarding nuclear materials, but first I want to appeal to any members of the working press who may be here tonight - a news release, in any form, on an airline bomb threat is an extremely delicate matter because it tends to stimulate more threats. All bomb threats, and particularly aircraft threats, reduce the safety factors in one form or another. For example, about two weeks ago BOAC had to divert to Denver because of a bomb threat. It was probably the first time that crew had ever been in there, and its such things as this that reduce safety. The two points I want to make involve the kind of discussion that I'm trusting that any member of the press here will, in his good judgement, find is not newsworthy. I know that the members of the press will understand and cooperate, as they have done in the past.

My first point concerns absolute accountability. At the present time, the only recourse most airlines have in bomb threats is to make an unscheduled landing as quickly as possible or to delay departure and thoroughly search the aircraft and luggage cargo. This is very expensive, and it is a serious inconvenience to the public, and sometimes involves a reduction in desired safety levels, as I mentioned. The reason why deplaning and searching is necessary is because there is no system that we have readily available now which will accomplish rapid mass screening of passengers, luggage, and the cargo to provide the subsequent reassurance that bombs or explosives did not get aboard. Fortunately, a vast majority of these threats are merely hoaxes. Some, however, and particularly recently, are tied to an extortion plot. The facts are that airlines simply cannot, and will not, take a chance because of what in effect is the lack of accountability with respect to explosive devices in the baggage or cargo. Now, if there were a threat involving a nuclear device, or perhaps radioactive materials, it would be extremely important to quickly confirm to the decision makers that all nuclear materials for which AEC and private sector are responsible can be accounted for.

The other point concerns publicity. Let's all hope against the filming of a movie or TV show involving nuclear extortion or a blackmail plot. Better yet, I would suggest a positive approach to the film industry, urging their understanding and cooperation in advance of such production. We have statistical data which relates to the viewing by the public of a film entitled "Doomsday Flight" with a significant increase in bomb threats against air carriers. "Doomsday," as you may know, or I'm sure you read about it recently in the papers, is a story about the use of a barometric explosive device and an extortion attempt against an airline. It first emerged in real life after its showing at Anchorage, Alaska, about a year ago, and it resulted in a successful $25,000 extortion plot against a U.S. air carrier. The next and most significant case was after its showing in Australia--the successful half million dollar extortion (more than that) against BOAC last May 26. Now, following a widespread publicity of the BOAC case, extortion-type bomb threats during the last two months, June and July of 1971, increased about six times over their normal monthly average for which we have accurate figures. Now you don't have to be a psychologist to understand that just as children mimic characters from cowboys and Indians, or the cops and robbers movies, there are a lot of adults and large-sized juveniles in our present society who are similarly influenced to the point of executing these games in real life. The Federal Aviation Administration has been generally successful in requesting TV stations across the country to withhold the showing of "Doomsday Flight" and Rod Serling, the author, is quoted in a recent wire service story that he wishes he had never written the thing. With the chilling thought that we can do without any kind of nuclear extortion threat even from crackpots, I suggest that the AEC may want to put the subject of publicity on its worry list. Bill?

Mr. Brobst:

It's there, Dan. It's there. Thank you. Bob Begeman, what's the insurance outlook on this particular problem?

Mr. Begeman:

It's obvious that Bill Brobst doesn't know better than to antagonize a Texan, and I'm going to teach him a little lesson now for about 15 seconds. When a Texan gets away from home and is introduced as such, everybody always snickers as you people did tonight. I won't go into the reasons why that's so. I'll leave that up to an ex-President that lives down there. The only thing worse than being a Texan away from home is being in the insurance business. Nobody likes an insurance man. A good example of that is an old farmer down in East Texas not long ago whose barn burned down. He had insurance and he filed his claim and the adjuster came out. He said, "Yes, it's a total loss. Rebuild it and send us the bill." And the farmer said, "No, I would much rather have the money, I don't need another barn." And the adjuster said "But we don't operate like that. Insurance is to replace your loss, and we won't give you the money, but we will give you another barn." And the farmer said, "All right, if that's the way you operate I'll have to go along with it. But he said, I'll tell you this much; the minute you get back to your office, I want you to cancel that policy you have on my wife."

The company I work for is owned and operated by the Motor Carrier Industry, and we insure some 250 to 260 large motor carriers in the U.S. The theft and hijacking problem is one of our biggest problems right now. It's just as big a problem to you as it is to the insurance industry, only we know it and you haven't found it out yet. I'm going to read to you a little excerpt of a letter I wrote to General Davis shortly after he was given his new responsibilities which outlines the experience that we, one small insurance company in one segment of the industry, had during the month of July. "On the first day of July, in Long Island City, at 2 p.m., the driver of a truck was hijacked by three gunmen, and a load of electric shavers valued at $58,000 was stolen. On the 12th day of July, in Masdeck, Long Island, at 8 o'clock in the morning, a driver was hijacked at gunpoint at a coffee stop and 193 portable TV sets with stands, valued at some $30,000, were stolen. On the same day in Brooklyn, New York, at 5:15 p.m., a driver was hijacked at gunpoint while stopped for a traffic light, and a load of coffee valued at $37,000 was stolen. On the 18th of July in Syracuse, New York, a partial load of color TV sets valued at some $47,000 were stolen. On the 22nd day of July, in Woodside, Long Island, at 5:30 p.m., five armed men hijacked a truck and trailer containing 667 packages of paper folders worth about $69,000, and they also hijacked the escort vehicle that they had going along with it." Now, actually we were quite fortunate because in all of these five instances, we only lost around $225,000 and it's not uncommon at all for the trucks that we insure to be carrying two and three hundred thousand dollars worth of merchandise in one truck. Now, as it happened, there was no radioactive materials in any of these vehicles, but each of the carriers involved are registered and certified to haul radioactive materials, and in three of the five cases, there was other miscellaneous freight on the truck other than the main items the thieves wanted, and there could have been radioactive material in there.

Now, ladies and gentlemen, it's an indictment, and a serious indictment, on the society in which we live when you can't drive a truck in broad open daylight in the biggest city in the world without the certainty that every X number of them is going to be hijacked at gunpoint. Three years ago this major theft, as we call it, where they take half truck loads or full truck loads of merchandise, was confined nearly entirely to the terminal properties of the motor carriers. The thieves would simply walk in and pick out the truck they wanted and drive off with it. But, because of some pressure from Senator Bible's committee and some pressure that we, the insurance agencies, put on the carriers, they have improved their terminal security now. A decided improvement. They have improved it to the point where the thieves now find it easier just to pull a gun and do it in broad daylight on the streets; and I don't know the answer - it is certainly economically impossible for a motor carrier to escort every motor truck that he has operating on the streets of New York City. And incidentally, in our experience nearly 90% of the theft and hijacking of this nature occur in what we call the "Boston-Washington Corridor" up and down the East Coast, and almost 90% of that 90% is in the metropolitan area of New York City. We have had several occasions recently (by recently I mean this year). For example, we had a carrier that had two truckloads of cigarettes on a pier in New York waiting to be loaded on ships. They were in line with some 15 or 20 other trucks waiting their turn. This was at 10 o'clock in the morning. People drove in with a closed Econoline type van (and this is the normal method of operation for them) held up our driver, put the drivers in the closed van, substituted their own driver, pulled these trucks out of line and at this particular dock, they had to go by the line of trucks and go down to the end and turn around because there was only one exit. When the FBI, the police, and our people went to investigate it, nobody saw nothing. (If you'll pardon my English - that's the way it was reported to us.)

This is what we are faced with - it's what you are faced with. One of these days, the American public is going to wake up to the fact that this thievery or thefts involved in innerstate transportation is costing you a tremendous amount of money, we'll forget that you're primarily concerned with radioactive and atomic energy material. But everything is transported on the railroad, in an airplane, on a truck, and on a ship today. You are paying more for it because of this theft problem, and the main reason for me being here tonight is to try to make you a little more aware of what the problem really is, to urge you to support such people as Senator Bible and Senator Magnuson in getting some legislation through and I don't know what we need, frankly. We certainly need quicker action in the courts, we need more vigorous prosecution, we probably need some more FBI agents, but something simply has to be done or you are going to be paying a lot more next year - in spite of the wage and price freeze. Thank you very much.

Mr. Brobst:

Thank you, Bob. I hope that you in the audience are all thinking about these things, because we will be asking you for questions later on in our panel, and asking our learned experts to answer them. Sam Edlow, you have looked at these problems from more angles than most of us, what is your reaction so far?

Mr. Edlow:

Let me take a minute to explain why our own company is interested in the problem, because I think our interest is probably going to be your interest now that you are becoming aware of the facts. First, we were interested in the problem as a matter of self-interest. Whatever the regulatory people do, they are going to do to us because we arrange shipments, and a good bulk of shipments we arrange are those in the category of strategic quantities of special nuclear material, and because these regulations will affect us, just as they will affect many of you in the group here who arrange for shipment, it is in our self-interest to obtain a knowledge of the problem and to work as much as possible with the regulatory authorities to assist them in devising regulations which can, in fact, be implemented. Secondly, in addition to being citizens of the United States, we are also citizens of the world. It happens that we in our company believe in nonproliferation, and if you, too, believe in nonproliferation, this must be a concern of yours, because the weak link in the chain of safeguards is the transportation cycle. Now, you are getting a feel for the facts of the transportation industry. Let me put it even a little bit more bluntly. The transportation industry as a whole is riddled with crime, is inefficient and, on the whole (with some exceptions) has really very little regard for the interest of its customers. That's quite a statement - later on I will be prepared to do what I can to substantiate this, and in view of this, and in the view of the very unwholesome environment in which we place cargo - forget the dollar value, dollar value is very high, but we can insure against that - the cargo is of strategic value. It becomes a matter of concern.

Mr. Brobst:

Thank you, Sam. We're all grateful for your ability to put these things in perspective for us. Jim Fernan, what's the situation in the trucking industry?

Mr. Fernan:

. . . . Also, trying to determine and find help for us from outside the industry; particularly from the field of law enforcement - particularly in the tremendous maze of laws that bear upon the right of the employer to freely select and check out the background on an employee he takes into his business.

In the absence of detailed data as to dollar losses in the motor carrier industry, we estimate, based upon the regulated carriers (the carriers regulated by the Interstate Commerce Commission) it would run about 1% of their earned revenues, which in this case would be 135 million dollars a year. This 135 million dollars includes claims paid for shortages and thefts identified as such. Shortages run about 4 times identified theft and pilferage. If you take the entire motor carrier industry, the interstate, the intrastate, and the local carrier, the loss from this source would be about 635 million dollars a year - assuming the 1% is accurate to start with, the extension would be correct.

To go back to the 135 million dollars lost by regulated carriers. We believe that about one fifth of that amount, less than one fifth of that amount, results from the catastrophic type losses - the hijacking - and the hijacking is taking a truck or tractor and trailer away from the driver with force or threat of force. We think that 80% of the losses occur in pilferages, either on the shipper's docks or when the shipment is in the hands of the motor carrier, or on the consignee's dock. This has to involve as suspect, those people in those industries, as well as outsiders to the industry.

I might observe, (not the least bit self-defensively), that in terms of total cost to the consumer, there is no figure accumulated in this nation for what the manufacturing industry terms shrinkage, from their production floors, from their storerooms, from their warehouses.

There are estimates with respect to losses in the retail industry, and the last estimate that I saw (and one that is repeated quite frequently) is 3 billion dollars a year divided up to about a billion and a half stolen by employees in the retail industry, and about a billion and a half stolen by shoplifters. I cannot readily agree with an indictment of the transportation industry as such. If we want to indict the whole private sector of the economy, then I will go along with it and talk about general morality.

With respect to the hijacks, the bulk of them occur in the "Boston-Phildelphia Corridor" and last year, as a matter of interest, there were 318 trucks hijacked in New York City, which is about a 100% increase over the prior year. The average cargo value on those trucks was around 25 thousand dollars, and that's a frightening figure standing in and of itself. But you get some idea of the difficulty in trying to protect the carriers by either the local police, state police or the Federal Bureau of Investigation - protecting trucks from being hijacked in New York City - when you realize that each day, 50 thousand trucks enter and leave New York City by one of the six major interstate entry and exit points. I don't know if my arithmetic is correct or not, but about 13 million trucks per year are in and out. I don't want to play statistics with you, but you would run out of zero's before you got to the percentage of losses.

I don't know quite how to relate this situation to the problem of possible loss of radioactive material in transit. Most all of the losses in the motor carrier industry are by people who are stealing something because its something they can use in their own household or for a gift for Aunt Nellie or Cousin June or is an item they can immediately convert into dollars - a readily saleable, commercial item. The consequences of hijacking losses are very, very painful to the motor carriers, but to my knowledge, and I believe Bill mentioned this earlier, up to this point in time there has not been a loss of radioactive material during the time it was in custody of the motor carrier industry and I trust this record continues. The other comment I would like to make is in respect to the matter of accountability of freight from the time it is picked up with the papers (and in keeping the two together) and moving that shipment promptly from the point of origin to the destination. Interest in the procedures that have already been set up from the safety standpoint is a tremendous plus for security of shipments of radioactive materials. In the dangerous articles handling guide, there are six pages devoted to who does what to whom by step, in series, from the time a trucking company gets the call to make a pickup. The other thing that I think of as an inherent guard against loss is the fact that most of the people working the trucking industry are frightened when they see a container labeled "radioactive materials." In fact, I have been told by some people that they have to specifically order a man to go over and get it and put it on the truck. He doesn't want to, he wants to get the hell out of where he is.

I do think that for the movement of the materials at nonpremium rate probably the track record to date has been good. What it is going to be I don't know and certainly that is one of the subjects that will be discussed here tonight.

Mr. Brobst:

Thank you, Jim.

Harry Murphy, how about the air industry? Would you care to rebut what Sam says? What do you think is the worst of all possible means of transportation?

Mr. Murphy:

May I leave now? Thank you for inviting me to be a member of this panel. I see that five of the six panelists are from Washington and the other one is from Dallas. I know that five of them are revenue paying passengers, and I hope all of you are. You folks are naturally concerned with two very important items when you ship material that is subject to AEC safeguards by air. Will the material be stolen? Will the plane be hijacked? The airlines consider this material to be what we call a high value item, and indeed it is. Prior to the delivery to an airport, the consignor certificate should be made out and all the packaging, labeling, packing, shipping, and temperature control regulations must be met. We recommend that the shipper deliver the material to the airline two hours before the flight time. The carrier will put the material on the airplane as one of the last items to be loaded so that it can be one of the first items off the plane. We recommend that the licensee's representative remain at the airport until the plane is in flight. At destination, we recommend that the authorized recipient be on hand when the plane arrives or within two hours after arrival. It is an axiom of security that the longer the chain of custody, the more likelihood there is of theft. If the consignee doesn't show up, we have to place this in our high value storage area. Its another step in the process and we don't like to do it. All this seems so simple, yet there still is a problem.

I was speaking the other day with a representative of the Office of Security of the Atomic Energy Commission and he said to me (these are his figures), "There were 3 thousand shipments by air last year, and there were five in which there were problems." In my opinion, its five too many and the problem is always the same - people are too casual. The shipper who routes the material on a plane which has several stops, instead of waiting another day and sending it nonstop or by the most direct service is being too casual. You have the right - exercise it (i.e., the routing choice). The offloading at the wrong place is being too casual. The employee of the consignee who takes his own sweet time in coming down to pick up the material is being too casual. Not following through on the Signature Service system that has been established is being too casual.

Gentlemen, I believe the system is good and its up to all of us to see that the system is always used. There are several ways to defeat the casual attitude and, in the airline industry, we use what we think are the two best ways of improving security in this regard; by training and by involvement. Creating security awareness in all personnel is the most important objective of any security officer in the transportation field or in any other. I worked, as Bill said, for 22 years in CIA, and naturally I worked in a security environment. The environment was created by the very nature of working in that atmosphere. You walked through a gate, you had your bag checked, on the way in. You went up to your office. There was nothing on your desk except an empty burn bag. You had to open a safe to obtain your working material. Anything you used was torn up and put in the burn bag and sent to the incinerator that night. This was a total security involvement. Bill mentioned that I wrote the book "Where's What?" I wrote it under a fellowship from the Brookings Institution in Washington while still employed by the Agency. The first day over there was a traumatic experience. I started writing something and I didn't like it, and I took it and I ripped it up - and then I looked; and I saw a waste basket; you don't throw waste paper in your waste baskets. I looked and looked and I think I looked at that waste basket for about five minutes before I said to myself, "there is nothing wrong with throwing the paper in there." That is what I mean by working in a security environment. I'm not recommending this for private industry, of course, because you must create the security awareness and the security environment consistent with operational efficiency. When we can reach the stage in which we create a good security environment in which to work, we will be able to almost close the security circle. In our own lives, we all strive to be better women and better men, but never quite make the perfect woman or the perfect man. It's the same way in security - you will never have perfect security, no matter what you are doing. The security officers' job is always to close that last little bit of the security circle. A recent method we have developed in New York City to help close the security circle is in connection with high value shipments. We use this in all the New York airports and this is what we call Regiscope cameras. These are dual lens cameras that simultaneously take a picture of the shipping document and the person who presents it.

We do have a gap in the security circle, and we look to Congress to help in this regard. The airline industry does not have the authority to have fingerprints of employees who handle mail and high value cargo checked through the criminal records of the FBI. The banks formerly had this right and they were doing it, but a month and a half ago, in the U.S. District Court for the District of Columbia, Judge Gesell said that such a check violates the constitutional rights of the individual. This is one of the things that we look to Congress for. I had the "happy" experience of appearing before the McClellan Committee. Senator Jackson, from your state, chaired the Committee at this particular time, and one of the questions asked me was, "Why don't you check the FBI record on your employees." When I said, "We don't have that authority," he just couldn't get over it - that we didn't have that authority. The chances of getting it at the present time are, I think, very slim, the mood of the Congress being what it is at the present time, but we will keep working for it or we will work for some other way to get this authority.

Now, hijacking aircraft transporting materials subject to safeguards has not been a problem. As Bill said to me before, maybe we have been lucky. Well, maybe we have been lucky, but in most instances, you'll remember that materials subject to safeguards move on cargo aircraft and we haven't had any freighters hijacked or skyjacked to my knowledge. The only passengers permitted aboard such aircraft are the couriers who escort classified materials. We continue to intensify all of our security efforts in connection with hijacking, and we work in very close cooperation with all governmental authorities. Dan Ward's office has been most helpful to us in this regard. I would like to state an interesting fact that's a by-product of the antihijack-deterrent program. The United States Marshals Service of the Department of Justice (not the "sky marshalls"), in the last 18 months have made 815 arrests as a byproduct of the anti-hijack program. Now, the first step in this program is the airline employee who refers the person who meets what we call our psychological profile of hijackers to the U.S. Marshal, so the airline employee must be doing something right in this regard if they've had 815 arrests and confiscated $1,500,000 worth of narcotics as a byproduct of this program.

Gentlemen, we are winning the battle against skyjackers; 43% of the skyjackers this year have been unsuccessful as compared to 30% last year - and 17% in '69. We are winning the cargo security battle in New York City. Since we have established the Airport Security Council in New York, there has been a percentage decrease in cargo theft in 1970 over 1969. There was 59% less in thefts in 1970 than 1969, and so far this year ('71), in the first six months, there have been 64.5% less than '70. With ten billion dollars worth of cargo moving through Kennedy Airport, the figures, in my opinion, will keep getting lower and lower, because we have the system and we have the resolve. As I mentioned, we are winning the battle against the skyjackers and we will lick the cargo security problem. An industry that has the management and resolve to make U.S. commercial aviation the fastest, safest, and best means of transportation is going to win the security war.

Mr. Brobst:

Ladies and Gentlemen - I would like the panel to have a crack at each other for a little bit. It seems like we have some different viewpoints. I get the feeling from the transportation people that everything is not so bad after all, but Sam Edlow tells us that it is hopeless. Dan Ward and Chet Smith talk about all the difficulties they are having in trying to make any real progress in this area. Is this problem really too big to solve; is it a billion dollars' worth of trade losses every year - something we can't do anything about? Harry, do you agree?

Mr. Murphy:

I don't agree with the figure at all. The 1 billion 470 million figure is one that has been devised by many means. In the airline industry last year, our claims paid totaled 13 million dollars. Assuming that we pay 50¢

on the dollar compared to the value of the actual merchandise, then the total amount of claims in the airline industry would be 26 million dollars, not 110 million dollars. The people who come up with 110 million dollars take everything possible into consideration when they are talking about this figure. They talk about things like "well - maybe the retailer lost a sale because of this, maybe the shipper was out money for a while." "He didn't have capital because the claim had to be paid." When we make a contract with a shipper, we are not entering into the sacred bonds of matrimony with them; we are making a contract with him to ship the freight.

Mr. Smith:

. . . . As a bailee for hire, with the commonlaw responsibility that a bailee for hire has; and when an airline today - and has for the last 40 years - different than any other type of carrier today . . . . A railway, truck, and a ship pays cash value for loss under the requirements that they have. Today the airline industry as it has for almost 50 years pays 50¢ per pound on any value. As an example today, you can ship your commodity in international transport, and the airline has to reimburse you at the rate of $7.52 per pound. Not in the United States! - by their domestic carriers today - oh no! They reimburse you 50¢ per pound. As an example, there was a theft of some 300 and some thousands worth of jewels or something like this in New York and the airline industry, which is a bailee for hire under the common law, (with the) requirements it had, paid that particular shipper about 300 dollars and that is the kind of problem, one of the problems, that the airline industry has - plus this fact: if the airline industry had to pay more of the cash value of the product that it handles, (it's a franchise carrier, that is the reason that it is given the authority to carry the products of the general public)--if it had to pay more dollars today out of its earning power, its security practices would be substantially greater than they are today, which permits these kinds of thefts to occur.

Mr. Fernan:

Could I stick my word in? Bill, I wanted to make this observation. I have no differences with the comments made by Mr. Smith or Mr. Ward. We're delighted as hell they are getting into the action.

For many of the reasons that Harry just mentioned, you cannot check a new hire out: I suppose that most of you people in here are "Q" cleared, which means that you have had, those of you who are, a complete background investigation back to your high school days. You go into the City of New York and hire a guy - you cannot get a fingerprint check on him, it is against the law in the City of New York; in fact, a couple of major air carriers were indicted last December because they got it extra-legally.

There is a new fair credit reporting act, basically a good law and a fair law. However, we have people all over the United States--and none of those doing the hiring are lawyers. I would like to emphasize the point that Chet made, in speaking for and quoting Senator Bible; that the transportation industry hasn't done as much as it could nor have the federal government, the state government, or the local government. Finally, I'll say this, nobody but nobody, is going to steal anything from anybody unless somebody will buy it. In Southern California, I'm told that about 40% of the merchandise stolen from motor carriers ends up peddled in flea markets. We have one near my home in New Jersey and you can't even get within five miles of it on a Saturday morning. People coming from New York, Philadelphia, and Delaware - for what reason? To get a good bargain. Thank you.

Mr. Murphy:

I don't want to start a who-struck-John thing with Chet Smith; but what we did in the industry is this: we took four of our largest carriers and we took the claims that we paid and then we went to see what the value of the merchandise was. Now, these four carriers represented almost 75% of the people who hauled freight by air. We took the claims paid figure and then we looked at the declared value of the shipment. It was just about twice the amount of the claims paid.

Mr. Begeman:

I'd sure like to be your insurance carrier rather than his truck route; we had to pay it all.

Mr. Edlow:

May I jump in with a comment? Now let me reverse myself and defend the gentlemen here. I was most impressed with the last sentence of Mr. Smith's opening remark, in which he quoted the Eighth Commandment, and in full justification to the transportation industry, let us all agree that we have an immoral society in which criminality is tolerated and that it is not just a specific of the transportation industry. But, let us make it clear, we don't deal with the department stores; we don't place our material in the department store environment; we place it in a specific environment. And regardless of the reasons why (and I would love to be in a symposium sometime on the morality of the American Society) but this isn't that one, let us recognize that we are placing it in this environment and that is the environment. And the second comment that I have to make, Mr. Murphy, is the same thing we went through with Signature Service - there is one tremendous difference between what the manual says and what happens. I'll give you one specific example: in the course of our interviews in connection with our AEC project, accompanied by a representative of the Atomic Energy Commission OSMM, we interviewed the Vice President of Security of a major airline. He told us the steps that they have taken to place security cages on our material and the steps taken to place other material of high value in security cages and so on--and by golly, that is what the manual says - and yet in Port Columbus, which is the airport of origin of all 90% and upward shipments of enriched uranium hexafluoride in strategic quantities, that airline doesn't have a security cage. And that Vice President in New York can tell me all he wants about security cages, but I'll walk into his cargo terminal and he doesn't have one in it. And the other airline has a security cage that is too small to accommodate 5 gallon drums; so then it is very difficult for us, the working people, the ones who are down on the ground, trying to look after our cargo, to accept manuals because there is a tremendous difference between reality and fiction in the security measures being taken by the transportation industry.

Mr. Fernan:

Could I make a comment? I sat in Washington at one of the security conferences last month and a high ranking member of one of the military services discussing the problems that exist in the military, which are not any different than the ones that exist in the private sector of transportation, was asked about losses they have on cargoes moved exclusively on military vehicles accompanied by military personnel. He said this, "We don't try to compare this with commercial sector." However, I happened to notice the last ten claims that we had; three of them involving military shipments, military vehicles, and military personnel - number one. Secondly, I think the real problem for consideration is what (and it has to come down to this) are the risks of loss. You people have to decide that. Finally, are you willing to pay for protection to provide this level of assurance or confidence that nothing is going to happen? As a fair matter, you really can't expect any carrier - whether an air carrier or motor carrier, or your neighbor next door - to give you extra protection for an item worth 137 thousand dollars per 50 pounds when you pay him no more to do it than you pay him to move 50 pounds worth of suitcases. And I think this, Bill, is an area where the shipper has to decide what kind of protection he wants, what the risks are. I don't think motor carriers can; I don't think the transportation industry can.

Mr. Brobst:

Jim, are you saying that you think the shippers ought to continue to pay a low freight rate and buy extra insurance?

Mr. Fernan:

No, I'm not proposing that. First of all, we want to continue to haul freight - that is what we are in business for. I just wanted to make the point that you can't, in good conscience or equity or whatever you want to call it, expect a carrier to take the risk of a 137 thousand dollar loss carrying a product from which he earns the same revenue that he does from hauling a product on which his loss is worth $50.

Mr. Edlow:

The point is well taken, the point is very well taken. Let's get specific. We are dealing with shipments in less than truckload quantities. Now let's see what you can do. You can ship exclusive use of equipment, you'll pay about 10 times the amount of freight that you would if you shipped less than truck load quantity. The question that has to be determined - what additional measures of security do you get for that; is it worth the difference in price? The whole question gets down to how much more are you willing to pay. But it goes farther than that; what do we get in return for it? Is it worth spending more money and do we get a compensating return. This is the question. You see, we in our company have made some conclusions, but we have a heck of a lot of questions left over. And there are options, and I think Bill would be the first to agree. He pointed out quite rightly, we either accommodate ourselves to the industry as it is, facing the facts of life; or the way it will be when it is better - but it won't be perfect. Or do we set up an all new environment. And there are optional ways of accommodating ourselves; I mean, without going into detail here, when you get into it there are ways of accommodating ourselves. Everything from armed escorts to the next step down, monitors, to the next step down, exclusive use; I mean there are many gradations. And the whole problem, and we don't have a solution yet, the whole problem is - how much money can we pay and what do we get, what actually does the transportation give us for that extra payment?

Mr. Brobst:

Something we have to remember though, Sam, is that, with the materials that we are speaking about, our concern goes beyond just compensation for the value of the material. We are speaking about materials that somebody might steal and make an atomic bomb out of and use it as a threat against the U.S. (As an example) "I've got two bird cages of plutonium and if you don't release all your prisoners and leave Viet Nam, I'll blow up New York City!" This type of national security value is something that cannot be compensated, cannot be considered, in the normal terms of transportation security.

Mr. Edlow:

Now, let me just take one more minute - let me give a specific example.

Mr. Brobst:

Just about one more minute and then I would like to get some questions from the audience. We are almost out of time, and I do want the panel to handle some questions from the floor.

Mr. Edlow:

All right, my example is very specific. Mr. Murphy knows and hinted at the fact - all of us ship our material by air NVD (no value declared). Now we can declare full value if we pay a premium. I think it is 25¢ a 100 dollar's evaluation. We can declare value, and I forget what the computation is, but the premium on a shipment of 3 packages has been rechecked and runs into a pretty sizable sum of money. But the question we asked, Bill, will the airline give us either increased security or what measure of security will it give us for our cargo if we pay them the premium. This is where the determination has to be reached. It isn't wise to spend money unless you get something in return for the money that you spend.

Mr. Begeman:

It is impossible for a Texan to keep his mouth shut over thirty minutes at a time, and I have done that and it has been 32 minutes since I said anything. First of all, in the five hijackings that I was talking to you about earlier, our investigation revealed that in 3 of 5 cases either the driver of the truck or the helper that was put on the truck had a past criminal record. Now, the truck lines are in the same position as the airlines are in, they are not allowed to check the criminal records, the FBI files, of their employees. I wrote the president of one of these truck lines a letter after we'd done a little checking and this one guy who was actually the escort of one of these loads that was hijacked and he got hijacked too, had been fired from another truck line about 3 months before that for stealing. Yet, here he shows up on our insured payroll, and he is put out to escort a load of high value merchandise. My statement to the president of this truck line was, "It is like sending a rat to guard cheese." He got irritated, but, of course, he wrote back that "This is what the union sent me, what the hell can I do?" I know a man of this type has no business guarding high value merchandise or have anything to do with the handling of it. This problem will not get any smaller until the American public gets tired of subsidizing these thieves, and that is exactly what you are doing. Everything you wear and everything that you're eating - everything that you're shipping - is costing more because of this criminal. And they order this stuff just like you place an order with Sears and Roebuck, or any other mail order store. They don't just order a load of liquor, they specify "I want a load of Jack Daniel's." This is true. When you, the public, get tired of this, it will be stopped - and it won't be until then.

Mr. Ward:

On this matter of fingerprinting and licensing, and trying to keep the criminal or the cheat from being one of your employers - this was discussed at the Cargo Security Conference this summer. Ben Davis, who was very active at the conference, promised he would put that matter on the agenda of the first interagency meeting, and he did. And he also directed that we include it in the cargo security work program. That little gem was soon found to be a very controversial issue with some obvious opposition to this sort of thing. There are a lot of people who say you can't do that because it is against the constitutional rights of the individual. Frankly, I don't know what we are going to do about it but the hopes of getting widespread personnel licensing are very slim. Harry Murphy recommended something at the Cargo Security Conference that we have cranked into our work program which makes real sense, because it is a little more narrowed down, and more manageable--that is - licensing of individuals to handle interstate cargo of extraordinary high value, and U.S. mail. Now, we might make some headway on those two items.

Mr. Brobst:

I would like some questions from the audience now please.

Question:

Would Mr. Ward care to give me the specific names of the people who raised these objections about the fingerprinting matter that you mentioned.

Mr. Ward:

Well, I would like to duck that one if I could.

Mr. Smith:

I can talk on that.

Mr. Brobst:

Okay Chet.

Mr. Smith:

Without going into too much length about it, the Bureau of Customs (Treasury Department) tried to do this late last year, insofar as international port customs operations were concerned, after our hearing and after the Assistant Secretary Recidies testified and indicated they were going to try and do this merely with the international airports and international seaports. They thought they had the legal authority to do this. They published in the Federal Register, their so-called "presumed order" in the rule making procedure; and all the roof fell in on them insofar as labor organizations were concerned, and the labor organizations convinced the Treasury legal people that they did not have that authority. That actual authority is now contained in legislation that the Treasury Department was able to introduce earlier this year; that particular legislation is now being before the Senate Finance Committee. That problem was alluded to by some very substantial labor unions at the Cargo Security Crisis sessions in June and July in Washington - and these are the labor unions you might just imagine would be those particular unions that this would be offensive to them. As far as Judge Kasell's opinion and the U.S. District Court and the District of Columbia, that particular matter is going on to the Appeals Court. They hope, as I understand it, to get to the Supreme Court on it immediately but on the basis of a constitutional question and not on the basis of whether the law is permitted. The constitutional question is obviously in a substantially different way as far as getting before the Supreme Court. In another piece of legislation that the Senate will take up as soon as it comes back on September 8, there are provisions for a commission on the safety and security of cargo that the President will appoint. The problem of fingerprinting of prospective employees will be one of those that is required to to be studied by that particular Commission with the hope that, with all the input of the private sector and the input of the labor sector, they may be able to come up with something in a substantial way to meet that particular issue within two years.

Mr. Fernan:

I was going to comment, in the District of Columbia in 1968, the matter of access to fingerprint records by private employers became a big issue. Some had contacts with the metropolitan police departments and got the whole "rap sheet," you know, from the time you threw a rock through a window and got caught when you were sixteen, all the way up. Other employers who did not have contacts didn't get anything. The Government of the District of Columbia formed a commission to discuss how to break the chain between a criminal record and unemployment. They held hearings and got testimony from every agency or group that you could imagine, including a society of exconvicts, which I didn't know existed. Maybe it was the local chapter, I don't know. As a result, they issued a rule in 1968 that when an applicant comes to you, a private employer, and wants to go to work, you can give him a sheet furnished by the police department, he signs his name at the bottom, you give him $1.50 and he goes to the Police who will give him a record of his convictions and/or forfeitures for the past ten years.

I might add a little self-serving statement that the trucking industry in that District is one of the greatest users of this, and the people in the trucking industry have spent many, many dollars and a half - that they give to the applicant. "Here's a dollar and a half, go down and get your record and bring it back," and you never see the man again. It is the best money you can spend.

Question:

What is the value of the recent AEC proposals involving monitors and terminal transfer points, with the labor problems we might have with shippers and employers of the carriers which go along with it.

Mr. Fernan:

I think the AEC, as the shipper of the material, certainly has the prerogative to require what they want and I don't think it would present any labor problems, management problems - or other kind of problems in the trucking industry.

Question:

You think that it would be effective?

Mr. Fernan:

I'm sure it would be effective if you had your own employees there and as nuclear material came through, they looked at it or counted it, or inspected, or checked it for radiation - yes, I'm sure they would do it. I don't know what it is going to cost you nor what you feel you are going to get out of it over and above what you are getting now. I don't think anyone in the carrier industry can answer that question. We can ask it, but we can't answer.

Mr. Murphy:

We actually have it in effective control at the point of origin and destination, but if you folks would want to send somebody out each time that it stopped to make sure that it was still on board, we would have no objection. It is like prayer, can't hurt and might help.

Mr. Smith:

What you really are talking about is like riding shotgun. Of course, the Post Office Department is presently riding shotgun on mail shipment in some of our airports today.

Mr. Edlow:

May I comment? Mr. Smith, I don't think that the monitoring concept is quite like riding shotgun. It is almost the same thing, but not quite. I think the comment is that it has to be examined in the context of what it is supposed to do. As I understand the monitoring concept - about which we had originally had very serious doubts until we made a study of it - now we think there is a point to it in the context of what it is supposed to do. It is not supposed to prevent diversion. It cannot prevent diversion. The duty of the monitor is not to carry a gun; he is not supposed to shoot anybody; he is merely to be at the transfer point to see that the material arrived where it was supposed to and that it was dispatched onward to the next place where it was supposed to go. In the concept of what the monitor is supposed to do, which is basically directed at the inefficiency of the industry not the criminality of the industry, then it is our opinion as a company that it serves a valid purpose - possibly on only a temporary basis, because we still have to examine from a long range whether our answer is accommodation with this environment or a new environment. And we do not foreclose the possibility of a new environment, a special environment, but as a temporary measure to vastly improve on what we have now, we think it is valid.

Question:

What can we do about hijacking and theft in international transportation.

Mr. Murphy:

You mean transport from the U.S., say, to the United Kingdom? Well it is the principle involved--as long as you have a good security system and the people follow it, then it will work. We have it controlled insofar as the hijackings are concerned; we have good controls over our international flights. This is where the sky marshals are on board those flights to prevent hijackings and we also have the departure controls. Incidentally, I last met Rex - and he doesn't remember me - in 1965. I was on the U.S. Commission to study the ability of the British to protect classified military information. I would like to say that Rex's group came off first rate.

Question:

If the DOT is spending any money on the automated detection systems, then if so how are you doing it?

Mr. Ward:

Yes sir, we are going to spend some money. Not to install automatic detection systems or locater beacons systems that you referred to, but through demonstration projects - a trial and error process with the Government picking up some of the tab on some of the errors that don't prove to be practical. This is a number one item on the work program in our new office, which has been set up less than 30 days. One idea is to select a trucking firm and I think Bob, here, can give us an idea of one that may not be doing too well. One that really has had it's problems with the hijacking, probably in the New York area, and try some gadgets and procedures that really don't have to be invented; they are available off the shelf, and simply need application. This is coming soon.

Mr. Brobst:

As the Chairman, I am going to take the prerogative of asking the last question, and I would like to direct it to Chet Smith. If the theft of special nuclear materials is such a drastic threat to our national security as we have heard described here, why doesn't the U.S. Government take over the transportation of these materials in total and pay the high cost? Why should the nuclear industry, one very small segment of our total gross national product, pay such a high price for a national security item?

Mr. Smith:

I think that particular question, of course, has a lot of facets to it. One of these is obviously the fact that the Congress must approve this to begin with insofar as the dollars that it provides ostensibly to the AEC to do this. For those particular shipments that are not government-owned, I assume that there could be amendments to the AEC act that would also provide this type of service for privately owned radioactive materials. I would think that this particular question is one that is coming--one of the reasons that some of us are here this evening talking about this particular problem. It is one that more people are paying more attention to today than they have for a matter of several years. Now I think this is again one that is going to have to be considered by the Commerce Department and by the Government as it proceeds with all these particular questions.

Obviously, one particular facet of the question you asked is that any time the Government takes over <u>anything</u> in which private enterprise has a stake, that particular ramification will be considered by the Government. Obviously this will be something that these people will have to talk about--whether or not there should be a Government operated transportation system to move radioactive materials.

To get back to the Senate Bill S9482, which the Senate Commerce Committee approved about a month ago and which the Senate will take up hopefully before the end of September and that will provide a ten member, presidentially-appointed Commission on the safety and security of cargo, the AEC has membership as one of the ex-officio members on that particular Commission in the the event that it becomes law. We would assume that this is a particular subject that the AEC would put into these particular discussions as far as the overall problem of the movement of the cargo and goods in this country is concerned. That particular Commission would have a life of two years; the president would name the members that would be cabinet members on it; each of the transportation departments would be represented; the two labor unions would be represented; shippers would be represented; all the transportation regulatory agencies, of course, would be ex-officio members; and there would be a two-year incisive study into the transportation system as it exists today, with respect to the problems that have come on in recent years insofar as theft and other aspects are concerned. I hope that it is responsive.

<u>Mr. Murphy</u>:

Bill, I would like to add that the airline industry wholeheartedly supports this Bill S9482, as well as another one the Senator Bible introduced recently - Senate Bill 2426. This is a bill that everybody can help out with. I'll give the background on it. Down in Georgia there was a trucking company that had some materials stolen. The material taken by the thieves was given to fences and then turned up in the hands of quote reputable businessmen - under Georgia law they were able to prosecute the thief, the fence, and the business man, collecting treble damages. Senator Bible has introduced a similar law to make it a Federal offense. Naturally, we wholeheartedly support that.

Mr. Brobst:

Ladies and gentlemen, we tried tonight to give you some food for thought. We tried to show that the problem that we live with in the AEC on transportation safeguards is only a part of the total problem. We have tried to give you a little bit of feel of the magnitude of that problem. We hope that you can take this information back, think about it, use it. When you watch the AEC labor through the development of solutions of some safeguard problems, we hope that the information you learned from this panel tonight will be able to help you better understand what we are trying to accomplish. I would like to thank each of the panel members for being here tonight and appreciate the time that you have taken from your own jobs to come here and give us the benefit of your experience and background in this area. I would like to thank each of you for your patient attention through this long session. Good night.