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TRANSPORTATION TECHNOLOGY QUICK REFERENCE FILE

Edited by

Edward W. Shepherd
Transportation Analysis and Information Division
TRANSPORTATION TECHNOLOGY CENTER

Sandia National Laboratories
Albuquerque, NM 87185

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ABSTRACT

This publication is a collection of items written by different authors on subjects relating to the transportation of radioactive materials. The purpose of the document is to meet the continuing need for information on specific subjects for dissemination to the public at their request. The subjects included were selected on the basis of the questions most often asked about radioactive materials and their transportation. Additional subjects are being considered and will be included in the future. The loose-leaf notebook format is used to facilitate the updating of this material. The data used in many of the papers represent the best available at time of publication and will be updated as more current information becomes available.

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109

CONTENTS

TRANSPORTATION TECHNOLOGY QUICK REFERENCE FILE

The Transportation Technology Center
History of the Center
Responsibilities
Approach
Organization

<u>Number</u>	
ITEM TTC/001	List of Acronyms
ITEM TTC/002	List of Definition
ITEM TTC/003	Accident and Incident Definitions
ITEM TTC/004	A Review of US Accident/Incident Experience Involving the Transportation of Radioactive Material (RAM) 1971-1980
ITEM TTC-005	Financial Protection Requirements and Indemnity Agreements for Damages Caused by Nuclear Incidents
ITEM TTC/006	State Legislation Governing Transportation of Radioactive Materials
ITEM TTC/007	Plutonium-239 Toxicity
ITEM TTC/008	Federal Preemption of State and Local Nuclear Transportation Regulation
ITEM TTC/009	Commercial Experience Involving the Transportation of Spent Fuel and High Level Waste in the United States
ITEM TTC/010	The Interstate Commerce Commission Cases
ITEM TTC/011	Factors in Transporting Radioactive Materials
ITEM TTC/012	The Risks of Transporting Spent Nuclear Fuel by Trucks
ITEM TTC/013	Transport Accident Rates
ITEM TTC/014	International Licensing of Casks and Other Type B Packages

TRANSPORTATION TECHNOLOGY QUICK REFERENCE FILE

The Transportation Technology Center

History of the Center

Sandia National Laboratories, with facilities in Albuquerque, NM, Livermore, CA and Tonopah, NV, is operated by Sandia Corporation for the Department of Energy (DOE) under a no-fee, no-profit contract with the Western Electric Company. About 70 percent of Sandia's resources are applied to defense-related research and development programs, primarily in support of nuclear weapons programs. Approximately 30 percent of the Labs' resources are applied to energy programs.

In 1978 the DOE established the Transportation Technology Center (TTC) at Sandia National Laboratories to support transportation responsibilities vested in DOE's Albuquerque Area Office. The Center was in direct response to the need to resolve problems posed by the present and future need to transport nuclear wastes produced by: (1) the government as by-products of its defense-related programs, and (2) the various portions of the commercial nuclear power industry.

Responsibilities

Assuring a national capability to analyze and resolve the complex problems of nuclear material transportation.

Assuring availability of transportation systems for national nuclear waste storage and disposal programs and providing a focal point for study of these systems.

Providing analyses and recommendations of transportation systems, in terms of their safety, reliability, public acceptability and cost-effectiveness.

Providing the interface between the various participants involved in the transport of radioactive materials.

Approach

The TTC efforts are directed toward determining and understanding the needs of private industry, government and the public. Further, through its own staff and through contractual efforts of private industry, government laboratories, consultants and universities, the TTC is actively seeking solutions to these problems inherent in nuclear material transportation.

To minimize redundant expense, the TTC integrates the DOE transportation program with those funded by the Department of Transportation, the Nuclear Regulatory Commission, other federal agencies and private industry.

Organization

The pivotal activity of "Systems Development" involves studies of total transportation systems for defense waste, for the domestic fuel cycle, for advanced reactors and

for the international fuel cycles. Specifically, these activities result in development or analysis of various types of packaging, vehicles and carrier systems needed for different transportation situations.

Supporting these activities is the TTC's "Technology" effort which provides the basis for systems development, for manufacturing and quality assurance and for any necessary certification. This effort includes development of full scale and fractional scale analysis and test techniques, and use of performance and proof-testing.

A third activity of the TTC is directed to "Institutional Issues" surrounding transportation of radioactive materials. These studies are aimed at obtaining a complete understanding of the needs and problems of the nuclear materials transportation industry; obtaining current data and performing analyses to indicate the trend of regulatory policy, legislative initiative and public acceptance of transportation and identifying the possible impacts of future changes. Studies also focus on quantifying risks of nuclear waste transportation and preparing material to assist in achieving public understanding of these risks.

The TTC also operates the "Technology Information Center" designed to systematically collect and disseminate relevant information. Information requests are met by using special computer data banks, staff reports and films and slide presentations about specific transportation issues. The TTC published a quick reference document containing short summaries of transportation issues. Based on questions and topics appearing prominently in the news media, scientific journals and other publications, this quick reference document covers topics such as state and local laws governing transportation of nuclear material, accident statistics, plutonium toxicity and insurance and liability issues.

May 1981
ITEM TTC/001

LIST OF ACRONYMS

AFR	Away-From-Reactor Storage
ACNS	Allied-General Nuclear Services, Inc., Barnwell, SC
ALARA	As-Low-As-Reasonably-Achievable
ALO	U.S. Department of Energy, Albuquerque Operations Office, NM
ANL	Argonne National Laboratory, Argonne, IL
ANSI	American National Standards Institute
BAM	Bundesanstalt fuer Materialpruefung, Federal Republic of Germany
BCL	Battelle Memorial Institute, Columbus Laboratories, Columbus, OH
BWIP	Basalt Waste Isolation Project
BWR	Boiling Water Reactor
CDS	Conceptual Design Study
CFR	U.S. Code of Federal Regulations
CHO	U.S. Department of Energy, Chicago Operations Office, Argonne, IL
CH-TRU	Contact-handled Transuranic Waste
CRBRP	Clinch River Breeder Reactor Plant
D&D	Decontamination and Decommissioning
DEIS	Draft Environmental Impact Statement
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DWPF	Defense Waste Processing Facility
EID	Energy Intensive Device
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPW	Experimental Program Waste
FEMA	Federal Emergency Management Agency
FFTf	Fast Flux Test Facility
FRA	Federal Railroad Administration
FSF	Fleet Servicing Facility
FY	Fiscal Year
GA	General Atomic Company, La Jolla, CA
HEDL	Hanford Engineering Development Laboratory, Richland, WA
HEF	Hot Experimental Facility
HLDW	High Level Defense Waste
HLW	High Level Waste
HMIR	Hazardous Materials Incident Report
HMPF	Hallam Nuclear Power Facility
IAEA	International Atomic Energy Agency, Vienna, Austria
ICB	Interface Control Board
IDO	U.S. Department of Energy, Idaho Falls Operations Office, ID
IMG	Interface Working Group
LASL	Los Alamos Scientific Laboratory, Los Alamos, NM
LLW	Low Level Waste
LMFBR	Liquid Metal Fast Breeder Reactor
LSA	Low Specific Activity
LWR	Light Water Reactor
MIS	Management Information System
MISTIC	Model Interstate Scientific and Technical Information Clearinghouse
MCSL	National Conference on State Legislatures
NE	U.S. Department of Energy, Office of Nuclear Energy
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
NSTF	Near Surface Test Facility
NTIS	National Technical Information Service, Springfield, VA

May 1981
ITEM TTC/001
Page 2

NWTS	National Waste Terminal Storage Program
OWNI	Battelle Memorial Institute, Office of Nuclear Waste Isolation, Columbus, OH
ORNL	Oak Ridge National Laboratory, Oak Ridge, TN
ORO	U.S. Department of Energy, Oak Ridge Operations Office, TN
PATRAM	Packaging and Transportation of Radioactive Material
PIR	Preliminary Information Report
PNC	Japanese Power Reactor and Nuclear Fuel Development Corporation
PNL	Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA
PSAR	Preliminary Safety Analysis Report
P-TRU	Processed Transuranic Waste
PWR	Pressurized Water Reactor
QA	Quality Assurance
R&D	Research and Development
RAM	Radioactive Material
RFP	Request for Proposal
RFQ	Request for Quote
RH-TRU	Remote-handled Transuranic Waste
RLO	U.S. Department of Energy, Richland Operations Office, WA
SAGSTRAM	Standing Advisory Group on Safe Transportation of Radioactive Material
SAR	Safety Analysis Report
SDD	Systems Design Description
SDT	Sub seabed Disposal Transportation Program
SF	Spent Fuel
SFS	Spent Fuel Storage Program
SFSC	Spent Fuel Shipping Cask
SNL	Sandia National Laboratories, Albuquerque, NM 87185
SPI	Slagging Pyrolysis Incinerator
SRO	U.S. Department of Energy, Savannah River Operations Office, SC
SRL	E.I. duPont de Nemours & Company, Inc., Savannah River Laboratory, Aiken, SC
SRP	E.I. duPont de Nemours & Company, Inc., Savannah River Plant, Aiken, SC
STF	Salt Test Facility
TIC	Technology Information Center, Oak Ridge, TN
TRU	Transuranic Waste
TRUPACT	Transuranic Package Transporter
TSSE	Transportation System Safety Evaluation Program
TTC	Transportation Technology Center
TTEIC	Transportation Technical Environmental Information Center
TNSO	Transuranic Waste Systems Office, Rocky Flats
TWTF	Transuranic Waste Treatment Facility
UKAEA	United Kingdom Atomic Energy Authority
WBS	Work Breakdown Structure
WEP	Work Element Plan
WIPP	Waste Isolation Pilot Plant
WV	West Valley, NY

For more detailed information contact Edward W. Shepherd (505 844-1740).

LIST OF DEFINITIONS

actinide	An element in the series beginning with actinium, atomic number 89, and continuing through lawrencium, atomic number 103.
activity (nuclear)	A measure of the rate at which a material emits nuclear radiation, usually given in terms of the number of nuclear disintegrations occurring in a given length of time. The standard unit of activity is the curie (Ci).
ALARA	As-low-as-reasonably-achievable. In the nuclear industry all radiation doses are maintained as far below prescribed standards as reasonably achievable.
alpha particle	A positively charged particle emitted in the radioactive decay of certain nuclides. Made up of two protons and two neutrons bound together, it is identical to the nucleus of a helium atom. It is the least penetrating of the three common types of radiation -- alpha, beta and gamma radiation.
aquifer	A water-bearing layer of permeable rock or soil.
atom	An electrically neutral particle of matter, indivisible by chemical means.
atomic number	The number of protons within the atomic nucleus of each chemical element.
atomic weight	The mass of an atom relative to other atoms.
back end of the fuel cycle	Includes reactors, spent fuel storage, fuel reprocessing, mixed-oxide fabrication and waste management.
background radiation	The varying radiation of man's natural environment. It results from cosmic rays and from the naturally radioactive elements of the earth, including those from within man's body.
beta particle	A negatively charged particle emitted in the radioactive decay of certain nuclides; a free electron.
biological half-life	The time required for an organism to eliminate, by natural processes, half the amount of a substance (such as a radio-nuclide) that has entered it.
boiling water reactor	A reactor system that uses a boiling water primary cooling system. Primary cooling system steam turns turbines to generate electricity.
by-product material	Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.
canister (storage)	A container for remote handled waste, spent fuel or high level waste, usually cylindrical. The waste will remain in this

	canister during and after burial in salt or other media. A canister affords physical containment but not shielding; shielding is provided during shipment by a cask.
cask	A massive shipping container providing shielding for highly radioactive materials and holding one or more canisters.
Certificate of Compliance	An approval of package designs issued upon demonstration that the package designs meet applicable performance standards.
chain reaction	A reaction that stimulates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and splits, releasing additional neutrons. A fission chain reaction is self-sustaining when the number of neutrons released equals or exceeds the number of neutrons lost by escape from the system or by non-fission absorption.
cladding	The outer jacket of nuclear fuel elements. It prevents corrosion of the fuel and the release of fission products into the coolant.
closed transport vehicle	A vehicle equipped with a securely attached exterior enclosure, which, during normal transport, restricts the access of unauthorized persons to the cargo space containing the radioactive material. The enclosure may be permanent or temporary, may be of the "see-through" type and must limit access from the top, side and ends.
Competent Authority	The official who is responsible for international interactions relating to transportation regulations. DOT is the national Competent Authority with respect to the regulations of the International Atomic Energy Agency (IAEA) and will issue Certificates of Competent Authority for the United States under those regulations.
commercial waste	Nuclear waste deriving from commercial sources. These are principally power reactors, but also include research laboratories and medical facilities.
contact-handled waste	Waste that does not require shielding other than that provided by its container.
containment vessel	The receptacle on which principal reliance is placed to retain the radioactive material during transport.
contamination	Undesirable radioactive material present on outside surfaces. This contamination can be either transferable or fixed. Radiation penetrating the walls of a waste package from within is not contamination.
critical mass	The minimum mass of fissionable material that, with a specified geometrical arrangement and material composition, will self-sustain a fission chain reaction.
criticality	The state of a mass of fissionable material when it is just sustaining a chain reaction.

curie (Ci)	A unit of measure of radioactivity; 1 curie = that quantity of any nuclide which undergoes 3.7×10^{10} disintegrations per second.
decay, radioactive	The decrease in the number of radioactive nuclei present in a radioactive material due to their spontaneous transmutation. Also, the transmutation of a radionuclide into another nuclide by the emission of a charged particle.
decommissioning	Preparation of worn-out or obsolete nuclear facilities for retirement. Decommissioning operations remove facilities such as reprocessing plants and burial grounds from service and reduce or stabilize radioactive contamination.
decontamination	The selective removal of radioactive material from a surface or from within another material.
defense waste	Nuclear waste derived from the manufacture of nuclear weapons and the operation of naval reactors. Associated activities such as the research carried on in weapons laboratories also produce defense waste.
deuterium	A natural isotope of hydrogen with one neutron and one proton in its nucleus (atomic weight = 2).
dose (radiation)	A general term indicating the amount of energy absorbed per unit mass from incident radiation. The standard unit of dose to humans is the rem.
dose equivalent	The product of absorbed dose and modifying factors that take into account the biological effect of the absorbed dose. While dose includes only physical factors, dose equivalent includes both physical and biological factors and provides a radiation-protection scale applicable to all types of radiation. Units are rem for an individual and man-rem for a population group.
dose rate	The rate at which dose is delivered.
encapsulation	A term used to denote an additional fabrication technique often used in preparation of radiation sources, wherein the basic material is physically placed within sealed, high physical integrity capsules or envelopes to provide further assurance that in the event a package breaks and the capsule escapes, there would be little possibility of a spread of radioactive contamination.
enriched uranium	Uranium in which the percentage of the fissionable isotope ^{235}U has been increased above the 0.7 percent normally found in natural uranium.
fault	A surface or zone of rock fracture along which there has been displacement.
federal repository	A United States government-controlled facility to be used for the disposal of nuclear waste.

fissile classes	The groupings into which radioactive material packages are classified according to the controls needed to provide nuclear criticality safety during transportation.
fissile material	Plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235 or any material containing any of the foregoing.
fission product	A nuclide produced by the fission of a heavier element or the subsequent daughter resulting from radioactive decay of the nuclide thus formed.
fissionable material	Any material fissionable by neutrons of all energies, such as certain isotopes of uranium and plutonium.
front end of the fuel cycle	Includes mining, milling, enrichment and fabrication of UO_2 fuel.
fuel (nuclear reactor)	Fissionable material used as the source of power when placed in a critical arrangement in a nuclear reactor.
fuel assembly	A grouping of fuel rods.
fuel cycle	The complete series of steps involved in supplying fuel for nuclear reactors. It includes mining, refining, enrichment, fabrication of fuel elements, use in a reactor, chemical processing to recover the fissionable material remaining in the spent fuel, re-enrichment of the fuel material, refabrication of new fuel elements and management of radioactive waste.
fuel element	A tube, rod or other form into which fissionable material is fabricated for use in a reactor.
fuel reprocessing plant (FRP)	Plant where irradiated fuel elements are dissolved, waste materials removed and reusable materials are segregated for reuse.
fuel rod	The smallest structurally discrete part of a reactor assembly which has nuclear fuel as its principal constituent.
gamma ray	Electromagnetic radiation, similar in nature to x-rays, emitted by the nuclei of some radioactive substances during radioactive decay.
generator	The producer of wastes or other nuclear material which is transported.
glove box	A sealed box in which workers, remaining outside and using gloves attached to and passing through openings in the box, can safely handle and work with radioactive materials.
half-life	The time required for a radioactive substance to decay to half its original value. After a period equal to ten half-lives, the radioactivity has decreased to about 0.1 percent of its original value. Distinct from biological half-life which is the time required for half of an ingested (or inhaled) substance to be eliminated by natural processes.

Hanford site	A 560 square mile DOE reservation in south-central Washington near the Columbia River. The nearest city is Richland, WA.
hazardous waste	A material which poses a potential risk to health, safety and property when handled, transported, stored or disposed of.
health physics	The science concerned with the recognition, evaluation and control of health hazards from ionizing radiation.
high level liquid waste (HLLW)	The aqueous waste resulting from operation of the first cycle solvent extraction system (or its equivalent) in a facility for reprocessing irradiated reactor fuels as well as concentrated wastes from subsequent cycles.
high level waste (HLW)	DOE management directives define high level waste to include high level liquid wastes, products from solidification of high level liquid waste and irradiated fuel elements if discarded without reprocessing. A proposed NRC regulation (10 CFR 60.3) defines high level waste to include irradiated fuel, high level liquid waste and products from its solidification.
interim storage	Storage operations for which (a) monitoring and human control are provided and (b) subsequent action involving treatment, transportation or final disposition is expected.
in situ	In the natural or original position. The phrase is used to distinguish in-place experiments, rock properties, and so on, from those in the laboratory.
ion exchange	A phenomenon in which chemical species in one phase or material exchange with similar species in another phase. Ion exchange usually refers to a particular process in an aquifer: the exchange of ions in the water for ions in or on the rocks.
isotope	Any of the two or more forms of the same element containing the same number of protons but different number of neutrons. The isotopes are chemically similar but have different atomic weights. Isotopes can be either stable isotopes or radioactive isotopes (also called radioisotopes).
large quantity radioactive materials	A quantity the aggregate radioactivity of which exceeds a Type B quantity and is sometimes referred to as "large source."
light water reactor (LWR)	May be either a boiling water reactor or a pressurized water reactor; uses as coolant ordinary water (H_2O) instead of heavy water (D_2O).
limited quantity radioactive materials	A quantity of radioactivity which does not exceed the limits specified in 49 CFR 173.391(a). Limited quantities and certain radioactive devices, 49 CFR 173.389(p), 173.391(b) and (c) are excepted from specification packaging, marking and labeling requirements, but still are subject to certain requirements, such as shipping paper requirements.
low level waste (LLW)	Waste which is not high-level or transuranic.

low specific activity material (LSA)	Radioactive material in which the activity is essentially uniformly distributed and in which the concentration of radioactivity is low.
manifest	A form of delivery document used for identifying the quantity, composition and the origin, routing and destination of the hazardous waste shipment.
man-rem	A unit of population dose; the total radiation dose commitment to a given population group; the sum of the individual doses received by a population segment.
matrix, waste	The material in which radioactive nuclear waste is encapsulated. The material, likely to be a glass, encapsulating reprocessed high level waste is contained in a canister.
mode	Any of the following transportation methods: rail, highway, air or water.
multibarrier	A system using the waste form, the container (canister), the overpack, and the emplacement medium as multiple barriers to isolate the waste from the biosphere.
natural background radiation	Radiation in the human environment from naturally occurring elements and from cosmic radiation.
neutron	An uncharged elementary particle with a mass nearly equal to that of the proton. Neutrons sustain the fission chain reaction in a nuclear reactor.
nonproliferation	Limits the number of nations capable of producing nuclear weapons without limiting worldwide use of nuclear power.
normal form radioactive material	Normal form radioactive materials are grouped into transport groups and include those materials which do not meet the requirements of special form radioactive materials.
nuclear criticality	This term denotes the occurrence of a chain reaction with fissile radioactive materials. The purpose of the fissile classes is to prevent the occurrence of nuclear criticality during the transport of fissile materials. (Controlled nuclear criticality is the objective within a nuclear power reactor.)
nuclear reaction	Result of the bombardment of a nucleus with atomic or subatomic particles or very high energy radiation. Possible reactions are emission of other particles or the splitting of the nucleus (fission). The decay of a radioactive material is also a nuclear reaction.
nuclear safety	The application of technical knowledge and administration control to prevent an unplanned, uncontrolled nuclear chain reaction.
nucleus	The positively charged center of an atom, consisting primarily of neutrons and protons, which make up almost the entire mass of the atom but only a minute part of its volume.

nuclide	A species of atom characterized by its mass number, atomic number and nuclear energy state, provided that the mean life in that state is long enough to be observable.
nuclide inventory (radionuclide inventory)	A list of the kinds and amounts of radionuclides in a container. Amounts are usually expressed in activity units: curies or curies per unit volume.
order of magnitude	A factor of ten.
overpack	A container put around another container; secondary (or additional) external packaging for packaged nuclear waste.
placarding	Application of the appropriate placard to the transport vehicle (rail or highway) if any radioactive package on board bears a "Radioactive Yellow-III" label.
pool or pool cell	A concrete chamber filled with water to provide shielding for irradiated fuel elements.
population dose	The sum of the radiation doses received by the individual members of a population.
rad (radiation absorbed dose)	The basic unit of absorbed dose of ionizing radiation. One rad is equal to the absorption of 100 ergs of radiation energy per gram of matter.
radiation level	A term sometimes used instead of radiation "dose rate" or "exposure rate." It generally refers to the effect of radiation on matter, that is, the energy imparted to and absorbed by matter due to emitted radiation per unit of time.
radioactive material	Any material or combination of materials which spontaneously emits ionizing radiation, and has a specific activity greater than 0.002 microcuries per gram.
radioactivity	The spontaneous decay of disintegration of unstable nuclei accompanied by the emission of radiation and particles.
radioisotope and radionuclide	For the purpose of transportation, these terms are synonymous with "radioactive materials" and identify specific isotopes of chemical elements that have radioactive properties.
radiotoxicity	A term used to denote the relative hazards of the various radionuclides, that is, their internal radioactive effect within the body.
Radiation Protection Guide	The officially determined radiation doses that should not be exceeded without careful consideration. These standards, originally set forth by the ICRP and the NCRP are now part of EPA regulations. They are equivalent to what were formerly called Maximum Permissible Exposures.
reactor (nuclear)	A device in which a fission chain reaction can be initiated, maintained and controlled.

rem (roentgen equivalent man)	A unit of individual dose equivalent used in radiation protection. It is the product of the absorbed dose in rads and factors related to relative biological effectiveness.
reprocessing	The process by which spent fuel from a reactor is separated into waste material and uranium and plutonium to be reused as nuclear fuel.
retrievability	Capability to remove waste from its place in isolation. The method and rate of removal and the subsequent location of the waste must satisfy retrievability criteria.
risk	Product of the consequences and the probability of an event's occurrence.
roentgen	A unit for measuring x-rays or gamma radiation. The roentgen is defined by measuring the effect of the radiation on air. It is that amount of x-rays or gamma radiation required to produce ions carrying one electrostatic unit of charge in one cubic centimeter of dry air under standard conditions.
shielding	The material interposed between a source of radiation and the environment for protection against the danger of radiation. Common shielding materials are concrete, water and lead.
shipping cask	A specially designed container used for shipping radioactive materials (see cask).
source material	Uranium or thorium or any combination thereof in any physical or chemical form, or ores which contain by weight 0.05 percent or more of uranium, thorium or any combination thereof. Source material does not include special nuclear material.
source term	The kinds and amounts of radionuclides that make up the source of a potential release of radioactivity. See nuclide inventory.
special form radioactive materials	Those materials which, if released from a package, might present some direct radiation hazard, but would present little hazard due to radiotoxicity and little possibility of contamination.
special nuclear material	Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235 or any material artificially enriched by any of the foregoing.
spent fuel (SF)	Nuclear reactor fuel that has been used to the extent that it can no longer be used in a nuclear power plant.
storage	Use of the word storage implies keeping open the possibility of retrieving the waste for reprocessing, for moving it elsewhere, etc. Storage usually implies the need for continued surveillance.
storage pool, spent fuel	A water-filled and cooled basin in which spent fuel is stored before being sent away for reprocessing or disposal.

**FINANCIAL PROTECTION REQUIREMENTS AND INDEMNITY AGREEMENTS
FOR DAMAGES CAUSED BY NUCLEAR INCIDENTS**

Liability protection for the nuclear industry is largely governed by the Price-Anderson Act (42 U.S.C. §2210). The Price-Anderson Act is designed to assure through a system of private insurance, retrospective premiums, and government indemnity, that the public would be protected in the event of a nuclear accident connected with a facility operated under a contract with or license issued by the government. Such an accident is and has always been considered extremely unlikely. However, Congress wanted to assure that there would be protection should the unlikely occur and the resulting loss or damage exceed that which could be expected to be covered by private insurance.

Under Price-Anderson, the Department of Energy and the Nuclear Regulatory Commission are authorized to enter into indemnity agreements with contractors and licensees operating nuclear facilities. Through indemnity agreements with licensees, financial protection is currently afforded up to a limit of \$560,000,000 per accident. The financial protection afforded contractors is currently \$500,000,000. If damages should exceed the protection limits, Congress has provided in the Price-Anderson Act that it will "thoroughly review the particular incident and will take whatever action is deemed necessary and appropriate to protect the public from the consequences of a disaster of such magnitude." Thus, even the \$560,000,000 limit may not be absolute.

Indemnity agreements authorized by law are very broad in scope. They cover not only accidents occurring at the site of contractual or licensed activity, but also accidents that might occur in the transportation of material to and from the site. The indemnity extends not only to the person or entity with whom and to whom the contract or license is extended, but any other person who may be liable to the public in connection with the incident. Liability covered by the Price-Anderson Act and related indemnity agreements remain covered even though the nuclear-related damage or injury is caused by terrorism, sabotage, or other illegal acts. The Nuclear Regulatory Commission concluded in a 1975 study that coverage under Price-Anderson would cease only if the damage or injury resulted from illegal actions after material is diverted from the site of indemnified activity or from the planned route of transportation.

Transportation liability coverage is afforded by the "umbrella" features of the Price-Anderson insurance-indemnity system. All modes of transportation are covered. Although the system covers nuclear liability from the first dollar loss, no one but the nuclear facility licensee or indemnified entity pays a premium or fee, if any, for such protection. The system further provides for interim emergency assistance payments to persons or entities affected by a nuclear incident without requiring them to sign a release or otherwise compromise their claims.

Additionally, transporters of nuclear materials can purchase liability coverage under the Supplier's and Transporter's Form in amounts up to \$160,000,000. This coverage is available principally to protect a carrier's liability arising out of the transport of nuclear material to or from locations other than nuclear facilities where indemnity agreements apply.

For more detailed information contact Omer Brown, Attorney, Office of General Counsel, U.S. DOE, Washington, DC 20585.

ACCIDENT AND INCIDENT DEFINITIONS

The terms, accident and incident, appear in many public, industry and government reports. Another major use of these terms is in the reporting of nuclear materials transportation incidents to the Department of Transportation (DOT), Materials Transportation Bureau. The definitions shown in this report are those commonly used for government publications and on the Hazardous Materials Incident Report (HMIR) that is required to be filed whenever an incident occurs.

Normal Transport

Normal transport is that transport which occurs without unusual delay, loss of or damage to the package, or an accident involving the transporting vehicle. (NUREG-0170, Volume I, Section 4.1)

Radioactive Material Transportation Incident

An incident is an event occurring during the course of transportation (including loading, transport, unloading and temporary storage) of radioactive materials which results in actual or suspected release of radioactive material. The event may include: fire, breakage, spillage, release or suspected release of radioactive material, excessive radiation, or suspected radiation, loss of possession or accident conditions.

This definition is not limited to incidents required by DOT regulations to be reported to the HMIR system (49 CFR 171.16-16, 174.750, 175.45(a)(4), 176.48(a) and 177.86(a)).

Handling Accident

Damage to a shipping container due to handling operations. Examples are package dropped in handling, run over by handling or transportation type vehicles or punctured by a forklift.

Radioactive Material Transportation Accidents

A radioactive material transportation accident is an incident in which the conveyance transporting a radioactive material package is involved in an accident. Accidents are subsets of incidents (see definition) and include a wide range of severities ranging from minor mishaps to the very severe.

Aircraft Accident

An aircraft flight accident resulting in aircraft damage as defined by the Air Force is "any aircraft mishap, occurring when there is intent for flight, which produces minor damage (minor accident) or substantial damage (major accident) or destruction (major accident/aircraft destroyed).

Minor damage - repair time 150-900 hours

Substantial damage - repair time greater than 900 hours

May 1961
ITEM TTC/003
Page 2

Damage is automatically classified as substantial for damage to certain major components such as wing center sections, horizontal stabilizers, etc., that is beyond repair.

Motor Carrier Accident

The definition of a motor carrier accident is consistent for Classes I and II interstate motor carriers of property as set up by the Bureau of Motor Carrier Safety, Federal Highway Administration and U.S. Department of Transportation. The definition includes all accidents that result in fatalities, injuries or property damage of \$250 or more.

Rail Accident

The rail accident is defined in the U.S. Code of Federal Regulations, Part 225, Section 225.21 (October 1, 1974) in that it includes accidents associated with the operation or movement of trains, locomotives or cars that result in railroad equipment, track or roadbed damage in excess of \$750.

For more detailed information contact Edward W. Shepherd (505 844-1740).

**A REVIEW OF US ACCIDENT/INCIDENT EXPERIENCE
INVOLVING THE TRANSPORTATION OF RADIOACTIVE MATERIAL (RAM) 1971-1980**

This paper analyzes the transportation accidents and incidents which have occurred in the United States in the period 1971-1980 and is based upon the information in a Radioactive Material Transportation Accident/Incident Data Base developed by the Transportation Technology Center (TTC) at Sandia National Laboratories. The major source of information for this accident/incident data base is data in the files of the Hazardous Material Incident Report (HMIR) system operated by the Material Transportation Bureau of the US Department of Transportation (DOT). Additional information was also obtained from the files of the US Nuclear Regulatory Commission (NRC). This paper summarizes US accident/incident experience and provides a concise statement of RAM package failure description for the transport modes of truck, rail, and air. This information represents US transportation experience for radioactive materials dating from 1971, the origination date of the HMIR system, to the present. The accident/incident data base is stored on TTC's on-line database management system for rapid storage, retrieval, editing and analysis of the accident/incident files.

The DOT regulatory requirements for reporting a hazardous material incident are specified by the Code of Federal Regulations (49 CFR, Para. 171.15). These regulations specify reporting after each incident that occurs during the course of transportation (including loading, unloading and temporary storage) in which as a direct result of moving hazardous material: (a) a person is killed, (b) a person receives injuries requiring hospitalization, (c) estimated carrier or other property damage exceeds \$50,000, (d) in the case of radioactive material there is suspected contamination, (e) etiologic agents are involved in the shipment, (f) continued danger of life exists at the accident scene. From this summary of the requirements for reporting a hazardous material incident, one can conclude that the requirements for reporting an incident vary widely. An examination of the detailed incident reports by the TTC staff revealed that not all of the reportable events were accidents, hence, the categorization shown in Table I is given so an up-to-date representation of US radioactive material transportation experience can be presented.

TABLE I
US Radioactive Material Accident/Incident Experience
(1971-1980)

Transportation Accidents	85
Handling Accidents	110
Reported Incidents	465
<hr/>	
TOTAL	660

In the interpretive analysis of the basic DOT and NRC information, a distinction is made between an accident and a reported incident. Two types of accidents are categorized, as shown in Table I. A reported incident will be classified as a transportation accident, for the purposes of this analysis, if there is a vehicular accident involving the vehicle transporting the radioactive material. Other incidents can be classified as handling accidents if during the course of handling, loading, etc. an accident occurs, for example, a package is dropped or run over by a piece of handling equipment.

The remaining classification, the reported incident, excludes transportation accident conditions. An example of a reported incident typically involves the detection of surface contamination on a radioactive material package or on a transport vehicle. These observations are often noted during loading or unloading operations. Such events generally involve no package failure, no release of radioactive contents and the absence of any accident conditions during transport. For this type of event the terminology "reported incident" has been used to accurately classify the reported event. The present US accident/incident experience is summarized in Table I. From Table I one can observe that for the total US experience to date, 85 transportation accidents and 110 handling accidents have occurred in the set of 660 total reported events.

The 85 transportation accidents listed in Table I can be classified by transportation mode as shown in Table II.

TABLE II
Radioactive Material Transportation Accidents by Mode

Transport Mode	Number of Accidents	Number of Packaging Failures
Air	5	1 Type A
Rail	5	1 Type A
Highway	75	39 Type A
	85	41 Packaging Failures

Table III summarizes some of the information that can be retrieved from the accident/incident data base. For example, the 85 transportation accidents involved a total of 711 radioactive material packages. Some accidents had only a single package onboard the transport vehicle. Other accidents involved a single transport vehicle with a number of packages on board. Table III traces an analysis of the radioactive material packaging failures in the 85 accidents.

The 41 packaging failures involved 38 Type A packages which released radioactive material. Since multiple numbers of packages can be carried on a single vehicle, it was possible to define five separate and distinct release events. Three of the release events occurred in an urban area. Two of the release events occurred in a non-urban area. For example, the Springfield, Colorado accident involved 29 packaging failures which released approximately 5400 kg of uranium oxide; this was defined as a single release event. The material released was described as uranium ore, radioactive sand (low specific activity) uranium oxide and radioactive material (RAM - not otherwise specified). It is interesting to note that an examination of the accident data reveals that 10 Type B accident resistant packagings were included in the set of packagings which were subjected to accident conditions, but produced no packaging failure and, consequently, no release of radioactive contents.

The information presented above represents a preliminary analysis of a transportation accident/incident data base for radioactive materials. The results of such an analysis can be used to provide information about the environmental impacts associated with the transportation of radioactive materials. In addition, such an analysis can

provide information which is useful in the formulation of the regulations governing the safe transportation of radioactive materials.

TABLE III
Transportation Accident Analysis Summary

RAM Packages Involved in Accidents	Radioactive Material Released	Released Description	Description of Material Released
Packaging Failures (with release)	38 Type A	5 Release--> 3 Urban ----> Events	*Uranium ore *Sand (LSA) *RAM (not otherwise specified)
		2 Non-Urban->	*Uranium oxide
Packaging Failures (no release)	3 Type A		
Packagings in Accident with No Failures	660 Type A 10 Type B		
	711		

For more detailed information contact James D. McClure (505 844-8753) or Eugene L. Emerson (505 844-4301).

**FINANCIAL PROTECTION REQUIREMENTS AND INDEMNITY AGREEMENTS
FOR DAMAGES CAUSED BY NUCLEAR INCIDENTS**

Liability protection for the nuclear industry is largely governed by the Price-Anderson Act (42 U.S.C. §2210). The Price-Anderson Act is designed to assure through a system of private insurance, retrospective premiums, and government indemnity, that the public would be protected in the event of a nuclear accident connected with a facility operated under a contract with or license issued by the government. Such an accident is and has always been considered extremely unlikely. However, Congress wanted to assure that there would be protection should the unlikely occur and the resulting loss or damage exceed that which could be expected to be covered by private insurance.

Under Price-Anderson, the Department of Energy and the Nuclear Regulatory Commission are authorized to enter into indemnity agreements with contractors and licensees operating nuclear facilities. Through indemnity agreements with licensees, financial protection is currently afforded up to a limit of \$560,000,000 per accident. The financial protection afforded contractors is currently \$500,000,000. If damages should exceed the protection limits, Congress has provided in the Price-Anderson Act that it will "thoroughly review the particular incident and will take whatever action is deemed necessary and appropriate to protect the public from the consequences of a disaster of such magnitude." Thus, even the \$560,000,000 limit may not be absolute.

Indemnity agreements authorized by law are very broad in scope. They cover not only accidents occurring at the site of contractual or licensed activity, but also accidents that might occur in the transportation of material to and from the site. The indemnity extends not only to the person or entity with whom and to whom the contract or license is extended, but any other person who may be liable to the public in connection with the incident. Liability covered by the Price-Anderson Act and related indemnity agreements remain covered even though the nuclear-related damage or injury is caused by terrorism, sabotage, or other illegal acts. The Nuclear Regulatory Commission concluded in a 1975 study that coverage under Price-Anderson would cease only if the damage or injury resulted from illegal actions after material is diverted from the site of indemnified activity or from the planned route of transportation.

Transportation liability coverage is afforded by the "umbrella" features of the Price-Anderson insurance-indemnity system. All modes of transportation are covered. Although the system covers nuclear liability from the first dollar loss, no one but the nuclear facility licensee or indemnified entity pays a premium or fee, if any, for such protection. The system further provides for interim emergency assistance payments to persons or entities affected by a nuclear incident without requiring them to sign a release or otherwise compromise their claims.

Additionally, transporters of nuclear materials can purchase liability coverage under the Supplier's and Transporter's Form in amounts up to \$160,000,000. This coverage is available principally to protect a carrier's liability arising out of the transport of nuclear material to or from locations other than nuclear facilities where indemnity agreements apply.

For more detailed information contact Omer Brown, Attorney, Office of General Counsel, U.S. DOE, Washington, DC 20585.

STATE LEGISLATION GOVERNING TRANSPORTATION OF RADIOACTIVE MATERIALS*

The transport of radioactive material is controlled by numerous legislative and regulatory actions at the federal, state and local levels. The Nuclear Legislative DataBase (NLDB) system, developed at Oak Ridge National Laboratory with funding provided by the Transportation Technology Center (TTC) of Sandia National Laboratories, is designed to provide for the collection, storage and retrieval of regulations and legislation pertaining to the transportation, disposal and storage of radioactive materials. Emergency response and power plant information can also be accommodated.

The NLDB data can be retrieved for thirteen (13) basic pieces of information for each regulation and legislative action in each of the states. The legislative information categories include legislative identification numbers, key provisions of the bills, agencies involved in the writing of regulations and their enforcement and an abstract of the legislation.

There are over 900 data entries currently and procedures to complete the basic data input and to update the data have been implemented. The attached tables on the legislative profile of the fifty states indicate the extent of the information now stored and available for retrieval. The states are arranged into six regions to facilitate the display of information, but other combinations are easily generated.

The state tables give only an overview description of the legislative situation. Complete documentation for each (*) mark in the tables is available from the Transportation Technology Center, Department 4550, Sandia National Laboratories, Albuquerque, NM 87185, or the Radiation Effects Information Center, Oak Ridge National Laboratory, Oak Ridge, TN 37830.

ATTACHMENTS

I Definition of Terms Used on State Tables

State Statutes Governing Transportation of Nuclear Materials (see chart on page 2 for regions)

- II Region 1
- III Region 2
- IV Region 3
- V Region 4
- VI Region 5
- VII Region 6

VIII Local Statutes Containing Restrictions on Transportation of Some or All Nuclear Materials

*The provision of this information does not indicate any opinion by the Transportation Technology Center on the validity of any state statute or regulation governing the transportation of radioactive materials.

May 1981
ITEM TTC/006
Page 2

Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Alabama	Delaware	Arizona	Alaska	Illinois	Connecticut
Florida	District of	Arkansas	Idaho	Indiana	Maine
Georgia	Columbia	California	Montana	Iowa	Massachusetts
Louisiana	Kentucky	Colorado	Nebraska	Kansas	New Hampshire
Mississippi	Maryland	Hawaii	North Dakota	Michigan	New Jersey
North Carolina	Tennessee	Nevada	Oregon	Minnesota	New York
South Carolina	Virginia	New Mexico	South Dakota	Missouri	Pennsylvania
	West Virginia	Oklahoma	Washington	Ohio	Rhode Island
		Texas	Wyoming	Wisconsin	Vermont
		Utah			

For more detailed information contact E. W. Shepherd (505) 844-1740 or Cathy Fore
(615) 574-7769.

DEFINITION OF TERMS USED ON STATE TABLES

1. **Routing** - State regulatory agency can specify acceptable routes for nuclear material shipments.
2. **Advance Notification** - Calls for advance notification to state agency by shippers before certain nuclear materials can be transported within state's boundaries.
3. **Permits/Fees** - Requirement to obtain a permit in advance of transportation of material and may also contain routing restrictions.
4. **Escorts** - Applies to shipments of formula quantities of special nuclear material, usually in the field of physical security.
5. **Time Restrictions** - Usually specifies time of day that shipments are allowed.
6. **Keeping/Access to Records** - Refers to maintenance of and access to records of nuclear material shipments, including those to be on-board the vehicle.
7. **Qualification of Personnel** - Specifies personnel requirements for guard and escort personnel as well as for other types.
8. **Accident Notification** - Requires accident notification of all carriers and specifies reporting requirements.
9. **Accident/Emergency Procedures** - Primarily a state responsibility and states are relied upon to specify requirements.
10. **Loading, Labeling and Marking of Packages, Unloading** - Specifies the requirements for the handling and marking of nuclear material containers.
11. **Financial, Liability, Insurance, Bonding** - Specifies protection limits for the public.
12. **Monitoring, Surveillance, and Inspection** - Applies to the physical condition of the equipment and to the packaging.
13. **Prohibitions** - Usually concerns routes.
 - A. **Certain Shipments** - Type of nuclear materials as well as modes and purpose of transportation.
 - B. **Certificate of Emergency Transport** - A type of permit which essentially prohibits the shipment.
 - C. **Turnpikes, Bridges, Tunnels, Ports** - See Attachment VIII for listings.
 - D. **Local** - Indicates states containing municipalities with restrictions (see Attachment VIII for listings).

STATE STATUTES GOVERNING TRANSPORTATION OF NUCLEAR MATERIAL

Region 1

	States						
	AL	FL	GA	LA	MS	NC	SC
1. Routing	-	*	*	-	*	*	-
2. Advance Notification	-	*	*	-	-	*	*
3. Permits/Fees	*	*	*	-	-	-	-
4. Escorts	-	*	*	-	-	-	*
5. Time Restrictions	-	-	*	-	-	-	-
6. Keeping/Access to Records	-	*	-	-	*	-	*
7. Qualification of Personnel	-	-	-	*	-	-	-
8. Accident Notification	-	-	-	-	-	-	-
9. Accident/Emergency Procedures	-	-	-	-	-	-	-
10. Loading, Labeling, Packing, Marking	-	*	*	-	*	*	*
11. Financial, Liability, Insurance, Bonding	-	-	*	-	*	*	-
12. Monitoring, Inspection, Surveillance	*	*	*	-	*	*	*
13. Prohibitions:							
A. Certain Shipments	-	*	*	*	-	-	*
B. Certificate of Emergency Transport	-	-	*	-	-	-	-
C. Turnpikes, Bridges, Tunnels, Ports	-	*	-	*	-	-	-
D. Local	-	*	*	-	-	-	*

STATE STATUTES GOVERNING TRANSPORTATION OF NUCLEAR MATERIAL

Region 2

	States						
	DE	DC	KY	MD	TN	VA	WV
1. Routing	-	-	-	-	-	-	-
2. Advance Notification	-	-	-	*	*	*	-
3. Permits/Fees	*	-	*	*	-	-	-
4. Escorts	-	-	-	-	-	*	-
5. Time Restrictions	-	-	-	-	-	-	-
6. Keeping/Access to Records	-	-	-	-	*	-	-
7. Qualification of Personnel	-	-	-	-	-	-	-
8. Accident Notification	-	-	-	-	*	-	-
9. Accident/Emergency Procedures	-	-	-	-	-	-	-
10. Loading, Labeling, Packing, Marking	-	-	-	-	-	*	-
11. Financial, Liability, Insurance, Bonding	-	-	-	-	-	-	-
12. Monitoring, Inspection, Surveillance	*	-	-	-	*	-	-
13. Prohibitions:							
A. Certain Shipments	-	-	-	*	*	-	*
B. Certificate of Emergency Transport	-	-	-	-	-	-	-
C. Turnpikes, Bridges, Tunnels, Ports	*	-	-	*	-	*	-
D. Local	-	-	-	*	*	*	-

STATE STATUTES GOVERNING TRANSPORTATION OF NUCLEAR MATERIAL

Region 3

	States									
	AZ	AR	CA	CO	HI	NV	NM	OK	TX	UT
1. Routing	*	*	*	*	-	-	*	-	*	*
2. Advance Notification	-	*	*	*	-	-	-	-	-	-
3. Permits/Fees	-	-	*	*	-	-	-	-	*	-
4. Escorts	*	*	*	*	-	-	-	-	-	-
5. Time Restrictions	-	-	-	-	-	-	-	-	-	-
6. Keeping/Access to Records	-	*	*	*	-	*	-	-	-	-
7. Qualification of Personnel	-	-	-	*	-	-	-	-	-	-
8. Accident Notification	*	*	*	*	-	-	-	-	-	-
9. Accident/Emergency Procedures	-	-	*	-	*	-	-	-	-	-
10. Loading, Labeling, Packing, Marking	*	*	*	*	*	*	-	-	*	-
11. Financial, Liability, Insurance, Bonding	-	-	-	-	-	-	*	-	-	-
12. Monitoring, Inspection, Surveillance	-	*	*	*	-	-	-	-	-	-
12. Prohibitions:										
A. Certain Shipments	-	-	*	*	-	-	-	-	-	-
B. Certificate of Emergency Transport	-	-	-	-	-	-	-	-	-	-
C. Turnpikes, Bridges, Tunnels, Ports	-	-	*	*	-	-	-	-	-	-
D. Local	-	-	*	-	-	-	*	-	*	-

[illegible]

STATE STATUTES GOVERNING TRANSPORTATION OF NUCLEAR MATERIAL

Region 5

	States									
	IL	IN	IA	KS	MI	MN	MO	OH	WI	
1. Routing	-	-	-	-	*	-	-	-	-	
2. Advance Notification	-	-	-	-	-	*	-	*	-	
3. Permits/Fees	-	*	*	*	-	*	*	*	-	
4. Escorts	-	-	-	-	-	-	-	*	-	
5. Time Restrictions	-	-	-	-	-	-	-	-	-	
6. Keeping/Access to Records	-	-	*	-	*	-	*	-	-	
7. Qualification of Personnel	-	-	*	-	-	-	-	-	-	
8. Accident Notification	*	-	*	-	*	-	-	-	-	
9. Accident/Emergency Procedures	-	*	*	-	*	-	-	-	-	
10. Loading, Labeling, Packing, Marking	*	-	-	-	*	-	*	-	-	
11. Financial, Liability, Insurance, Bonding	*	*	-	-	*	-	*	-	-	
12. Monitoring, Inspection, Surveillance	*	*	*	-	*	-	*	-	-	
13. Prohibitions:										
A. Certain Shipments	*	-	-	*	-	*	-	*	-	
B. Certificate of Emergency Transport	-	-	-	-	-	-	-	-	-	
C. Turnpikes, Bridges, Tunnels, Ports	*	*	*	-	*	-	-	*	-	
D. Local	*	-	-	*	-	-	-	*	-	

May 1981
ITEM TTC/006
ATTACHMENT VII

STATE STATUTES GOVERNING TRANSPORTATION OF NUCLEAR MATERIAL

Region 6

	States									
	CT	ME	MA	NH	NJ	NY	PA	RI	VT	
1. Routing	*	-	*	-	*	*	*	-	-	
2. Advance Notification	*	-	-	-	*	*	-	*	*	
3. Permits/Fees	*	*	*	*	*	*	-	*	-	
4. Escorts	*	-	-	-	-	-	-	-	-	
5. Time Restrictions	*	-	-	-	-	-	-	*	-	
6. Keeping/Access to Records	-	*	*	-	-	*	-	*	-	
7. Qualification of Personnel	-	-	-	-	-	-	*	-	-	
8. Accident Notification	-	*	*	-	-	-	-	*	-	
9. Accident/Emergency Procedures	-	*	*	*	*	-	-	*	*	
10. Loading, Labeling, Packing, Marking	-	*	-	-	*	*	*	*	-	
11. Financial, Liability, Insurance, Bonding	-	-	-	*	*	*	-	-	-	
12. Monitoring, Inspection, Surveillance	*	-	-	-	*	-	*	*	-	
13. Prohibitions:										
A. Certain Shipments	*	*	*	-	-	-	*	-	*	
B. Certificate of Emergency Transport	-	-	-	-	*	*	-	-	-	
C. Turnpikes, Bridges, Tunnels, Ports	*	*	-	-	*	-	*	*	*	
D. Local	*	-	*	-	*	*	-	-	*	

STATUTES AND ORDINANCES CONTAINING RESTRICTIONS ON TRANSPORTATION
OF SOME OR ALL RADIOACTIVE MATERIALS

Toll Roads

CT - Permit
FL - Shipments require Certificate of Authority
IN - Shipments require permit and special insurance certificate
LA - Spent fuel and high level waste banned
ME - Permit and 3-day advance notice
MD - Permit and 2-day advance notice
MA - Permit and consultant fee; banned on turnpike
NJ - Permit and special insurance certificate; banned on NJ turnpike
PA - Permit
RI - Permit
VT - Prior notice
VA - West Virginia Turnpike

Bridges

CA - Golden Gate Bridge, US-101, must secure escort
DE - Only under escort
FL - Documentation of NRC, DOT, ICC compliance
IL - Prior notification
IA - Prior permission of Iowa State DOT
LA - Spent fuel and high level waste banned
MD - Limited shipments, permit, 1-day notice; Harry W. Nice Memorial Bridge; Wm. Preston Lane Memorial Bridge; Susquehanna River Toll Bridge
MI - Prohibited on Detroit International Bridge; permit and advance notification on others
NJ - Banned on Burlington-Bristol and the Tacony-Palmyra bridges
NY - Banned on Atlantic Beach; other bridges require written permission, advance notification, inspections and only during certain hours
OH - Prohibited on Ironton-Russel and Portsmouth-Fullerton bridges
RI - Permit
VA - Weight limit on material plus package on Chesapeake Bay Bridge and tunnel; prohibited on Elizabeth River Bridge
Ontario, Canada - Prohibited on Bluewater Bridge

Tunnels

MD - Limited quantities under permit through Baltimore Harbor Tunnel; bans spent fuel
MI - Prohibited from International Toll Tunnel
NY - Prohibited from Brooklyn-Battery, Queens-Midtown and Verrazano-Narrows Bridge lower level; others require police escort and weight limits per package

Urban Areas

CA - Humboldt County (ban on nuclear waste shipments); Morrow Bay (shipments of high level waste require advance notification)
Marin County (ban nuclear waste shipments)

- CT - New London (spent fuel shipments prohibited except with a Certificate of Emergency Shipment*)
Middletown (hazardous wastes restricted; must have written permit; certain streets completely banned; could apply to radioactive materials)
- FL - Port of Miami (all shipments banned)
Tampa (carriers of radioactive material must stop at city limits and get fire department escort)
Ft. Pierce (carriers of radioactive material must stop at city limits and get escort from fire marshal office)
Ft. Walton (carriers of radioactive material must stop at city limits and get escort from city police)
Key West (carriers of radioactive material must stop at city limits and get escort from city police)
- GA - Atlanta (prohibit spent fuels and other radioactive materials except by Certificate of Emergency Transport; excludes national defense and nuclear medicine)
Garden City (prohibits nuclear wastes; less radioactive wastes require 78-hour notice and material type, route; aimed at stopping research reactor fuel into Savannah)
- IL - O'Hare airport (plutonium and enriched uranium banned)
- KS - Newton (a resolution request state of Kansas to enact legislation regulating nuclear materials)
- MA - Wendell, Plymouth (some restrictions)
- MD - Montgomery County (proposing legislation to regulate radioactive material)
- NJ - Cateret (bans radioactive material waste shipments)
- NY - New York City (spent fuel shipments require a Certificate of Emergency Transport*)
Suffolk County (prior notice required)
Binghamton (bans transport of spent fuel or rod from city maintained streets)
Binghamton (prior notification (48 hours) of transport of high level waste through city)
Geneva (no spent fuel or other high level waste by rail or truck through city without two weeks written notice and a \$100 permit fee; excludes defense material and low level waste for medical, etc.)
Mahopac (proposal to require one week notice, escort, evidence of trained driver and trucks marked)
Rockland County (certain radioactive materials require Certificate of Emergency Transport; exempts defense radioactive material)
Ithaca (prohibits transport or storage of high level radioactive material; exempts defense radioactive material (not waste) and medical and educational, which require two week notification to city police)
Syracuse (resolution requesting New York State legislature to promulgate rules and regulations permitting municipalities to adopt ordinances prohibiting spent reactor fuel transport through their cities; if transport is to be permitted then municipality can require thirty days notice, an escort, option to inspect vehicle and shipment and collect a fee to pay for above)
- OH - Beechwood, Brooklyn, Euclid, Lakewood, Mayfield Village, Maple Heights, Shaker Heights and South Euclid (spent fuel and other radioactive material shipments require a permit with notification of intent to ship provided two weeks in advance of shipment; does not require disclosure of defense information; must show urgent public policy need)
Cleveland (no radioactive material shipments through city; must use interstate around city)
- SC - Charleston (bans transport of spent fuel and other radioactive material that exceeds federally recommended levels of radiation; notify city police in writing at least 48 hours in advance to allow for an escort)
- TN - Nashville (spent fuel restrictions)
- TX - El Paso (limits spent fuel shipments to three major highway arterials and requires a permit from fire marshal)
- VA - Fairfax (requested Philadelphia Electric to avoid shipping fuel through county)

*Certificate of Emergency Transport - issued only for compelling reasons transcending public health and safety concerns.

PLUTONIUM-239 TOXICITY

Perhaps no other radioactive material has generated so great a controversy as plutonium. The current controversy about the radiological hazard of plutonium can be divided into three areas: factors in internal dosimetry, dose effect relationships and the actual (or perceived) public hazard of inhalation of insoluble plutonium particles.

The principal toxic hazard of plutonium is from inhalation of fine particles less than 10 microns in diameter. The re-distribution of this material into various organs of the body in time involves several factors whose values are a function of many variables and on which there is considerable legitimate disagreement. Inhaled plutonium dust is deposited fractionally in the naso-pharynx, trachea-bronchial and pulmonary areas of the respiratory system. The fraction of the dust transferring from each portion of the respiratory tract to a body organ or system, plus its effective half-life in the body, has been studied extensively, although the results have not always been quantitative or conclusive. The data derived from these studies provide the information needed to calculate radiation doses to various organs in terms of initial intake amounts. The most controversial parameters involved in this calculation are the measure of the biological damage done by alpha particles relative to gamma photons, the effective organ mass at risk, the relative sensitivities of various parts of an organ to radiation and the fractional distribution of the radioactive material to these parts and the effective half-life of the material in each organ (including both biological residence time and radioactive half-lives).

Once a specific dose is computed, how can that dose be related to a level of biological damage and/or to human health effects? Not all estimates of the toxicity of plutonium are accepted by specialists in the radiological field because biological half-life in various organs is not well established. For example, the U. S. National Committee on Radiation Protection and Measurement criticizes the conservatism in techniques used by health physicists as being too conservative, yet some researchers feel that the current limits are not conservative enough. No matter what techniques are used, the principal long-term health concern is the same--What carcinogenic effect will result from inhalation of plutonium dust? The lungs, bones and liver are the organs usually discussed with respect to plutonium-induced carcinogenesis. A significant amount of this concern revolves around lung cancer, especially specifying the quantity and nature of tissue at risk (i.e., which part and how much of lung is affected).

The actual (or perceived) public hazard of plutonium must involve evaluation, not only of the toxicity of plutonium, but also its dispersibility, atmospheric transport and the characteristics of the dispersed aerosol (particularly particle size distribution). Comparative "toxicological" assessment of plutonium in conventional terms may not be meaningful; toxic potency is an element but is not sufficient. Thus atmospheric emissions of a hazardous material may be projected to have a major impact on excess mortality in human populations, not because the toxicity of the particulates is very high, but because these pollutants enter the atmosphere, are inhaled and are deposited in the lungs. The most important considerations, then, are the conditions of exposure, amount of material deposited in the exposed population, the size of the population, and the period of time from exposure to the expression of the health effect.

There is a large body of experimental data concerning the physiological behavior and biological hazard of plutonium. The data has been subjected to generalizations, misstatements and honest differences of opinion amongst opponents and proponents of the use of plutonium in the nuclear fuel cycle.

In spite of these differences, certain generalizations are possible:

1. Plutonium is a toxic material and potential carcinogen.
2. Plutonium is neither the most nor the least toxic material used in or likely to be used in commercial ventures in the United States.
3. Appropriate safeguards and safety measures can be applied to minimize the likelihood of large scale releases of respirable plutonium to the atmosphere.
4. The mere existence of a plutonium reactor fuel program does not, in and of itself, imply that public hazard and loss of life is inevitable.

References

1. J. M. Taylor, A Perspective on Plutonium as a Radiological Hazard, a draft report dated March 1, 1978. A perspective based on a survey of 45 references.
2. B. L. Cohen, The Hazards in Plutonium Dispersal, a draft report issued in March 1975, by the Institute for Energy Analysis, Oak Ridge, Tennessee.

For more detailed information contact Edward W. Shepherd (505 844-1740).

FEDERAL PREEMPTION OF STATE AND LOCAL NUCLEAR TRANSPORTATION REGULATION*

This item examines the extent to which federal law preempts state and local requirements with respect to the transportation of nuclear materials, and concludes that federal law preempts some, but not all, state and local nuclear transportation requirements. The effect of possible Department of Transportation routing regulations on the issues is not considered in this report.

Under judicially developed doctrines for determining the preemptive effect of federal law, preemption analysis requires a two-stage inquiry: first to determine whether the federal law is valid; and second, if the federal law is valid, to determine whether state law interferes with the federal design. Because the commerce clause of the U. S. Constitution unquestionably authorizes the federal government to regulate nuclear energy, this item focuses on the second stage of the analysis. In determining whether state law interferes with federal law, three doctrines are relevant: express occupation of the field, implied occupation of the field and the principle of conflict. Under the doctrine of express occupation of the field, federal law displaces all state regulation in a particular area when Congress expressly manifests an intent to do so. Under the doctrine of implied occupation of the field, federal law displaces all state regulation in a particular area when Congress impliedly manifests an intent to do so. Indicators of such an implied intent are the pervasiveness of federal regulation in the field, and the dominance of federal over state interests in the field, including the federal interest in uniformity. When Congress has clearly not intended to occupy a field to the exclusion of the states, federal law still preempts particular state laws that conflict with the federal scheme. Such conflict may be either actual or potential. Actual conflict arises when compliance with both federal and state law is physically impossible. Potential conflict arises when state law stands "as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress."

To place the preemption doctrine in the context of the federal scheme for regulation of nuclear energy requires consideration of three federal statutes: the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974 and the Hazardous Materials Transportation Act. The Atomic Energy Act probably preempts state and local regulation (1) having to do with physical security, (2) having to do with the packaging of materials for which NRC sets packaging standards (unless within the scope of a valid Section 274 agreement) and (3) actually or potentially conflicting with Atomic Energy Act objectives, including the development of nuclear power. The Hazardous Materials Transportation Act expressly preempts any state or local requirement that is inconsistent with a requirement in the Act or a regulation promulgated thereunder, unless upon application the Secretary of Transportation determines that the state or local requirement affords at least as much protection as the corresponding federal requirement and does not unreasonably burden commerce.

These principles can be applied to various categories of state and local transportation requirements on a generic basis. State and local requirements relating to the following matters are probably preempted: routing restrictions and prohibitions on certain shipments; escorts (for formula quantities of special nuclear material); personnel qualifications (for formula quantities of special material); packaging (except by agreement states acting within the scope of their agreement). State and local requirements relating to the following matters are preempted only if they seriously burden

*This article was abstracted from the PATRAM 80 Compact, SAND80-0904A, TTC-0105, by R. T. Reese and F. A. Morris. The purpose is to provide background information on the subject and does not reflect any policy areas of the U.S. Department of Energy.

May 1981
TTC/008
Page 2

the development of nuclear power or come into conflict with specific requirements of the Hazardous Materials Transportation Act: records and manifests; personnel qualifications; labeling, storage, loading, handling requirements; insurance and bonding; registration, fees, permits and licenses. The following types of requirements are probably not preempted: advance notification; accident notification; accident emergency response procedures. Monitoring and inspection requirements are probably preempted if the underlying state substantive requirement they are designed to enforce is itself preempted.

For more detailed information contact Robert T. Reese (505 844-0443) or Edward W. Shepherd (505 844-1740).

COMMERCIAL EXPERIENCE INVOLVING THE TRANSPORTATION OF SPENT FUEL AND HIGH LEVEL WASTE IN THE UNITED STATES*

Introduction

The purpose of this item is to present information on the experience in the United States involving the transportation of spent fuel and high level waste.¹ A short summary of the U.S. spent fuel policy and the U.S. commercial shipping experience for spent fuel is presented. A review of the transportation incident/accident experience for spent fuel or similar transport systems is also included. This information was obtained from the available records of the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC). The details of the transportation and handling of spent fuel from the U.S. Navy's nuclear propulsion program are not available except to say that it is an integrated program involving standardized casks and handling systems from several port sites to a reprocessing facility.

U.S. Spent Fuel Policy²

In October 1977, the U.S. Department of Energy (DOE) announced a Spent Fuel Storage Policy for nuclear power reactors. Under this policy, as approved by the President, U.S. utilities will be given the opportunity to deliver spent fuel to U.S. government custody in exchange for payment of a fee. The U.S. government will also be in a position to accept a limited amount of spent fuel from foreign sources when such action would contribute to meeting nonproliferation goals. Under the new policy, spent fuel transferred to the U.S. government will be delivered, at user expense, to a U.S. government approved storage site.

U.S. Commercial Experience¹

In the United States, it was originally planned that spent fuel would be reprocessed several months after its discharge from the reactor, and the recovered uranium and plutonium recycled shortly thereafter. The actual recorded shipments of spent fuel show that shipments have been made to two reprocessing facilities, Nuclear Fuel Services' (NFS) West Valley, New York plant (which is currently inactive) and the General Electric Company's Morris, Illinois plant (GE-MSF). Actual reprocessing of commercial spent fuel has occurred only at NFS. Another reprocessing facility is located at the Allied-General Nuclear Services' (AGNS) Barnwell, South Carolina plant. Due to changes in U.S. policy with regard to reprocessing, the Barnwell facility has not yet received a license from NRC.

NFS has received approximately 2000 spent fuel assemblies and much of this material has been reprocessed. The NFS storage capacity is 925 fuel assemblies (either BWR or PWR). GE has in storage approximately 1200 assemblies of various types. GE can store 700 metric tons and has pending a request to increase their capacity by an additional 1100 metric tons. This storage capacity can be converted to numbers of fuel assemblies if we assume nominal values of .5 MT/PWR assembly and .2 MT/BWR assembly.

*This item appeared in the International Atomic Energy Bulletin, Vol. 21, No. 6, December 1979. Some data are no longer current. Updates to this paper will be issued when more current data are available.

Table 1. Characteristics of Spent Fuel Casks Available in the United States

Cask Type	Primary Transport Mode	Height Loaded Tonnes	Capacity in Elements PWR/BWR	Fluid in Cavity	Cavity Length/Dia (cm)	Design Heat Generation Rate (kw)	Major Shielding	Neutron Shielding	Number of Casks Available	Number of Casks Ordered
NAC-1 ^a NFS-4	Truck	22.25	1/2	Water/ Air	452/34.2	11.5	Lead & Steel	Borated Water Antifreeze	3	
NLI-1/2	Truck	21.4	1/2	Helium	452/32	10.6	Lead & Steel	Water	5	
NLI-10/24	Rail	86.6	10/24	Helium	404/114	77	Lead & Steel	Water	2	12
TN-8	Truck/ Rail	35.7	3 PWR	Air	427/170	35.5	Lead & Steel	Borated Solid Resin	2	2
TN-9	Truck/ Rail	33.9	7 BWR	Air	452/170	21.5	Lead & Steel	Borated Solid Resin	2	1
GE-IF-300	Rail	60.7	7/16	Water/ Air	458/95.2	61.5	Uranium & Steel	Water/ Glycol	3	
NAC Nuclear Assurance Corp. NFS Nuclear Fuel Services NLI National Lead Company TN Transnuclear GE General Electric Co. IF Irradiated Fuel			^a NAC-1 and NFS-4 are of the same design				U.S. Energy Research & Development Administration, Alternatives for <u>Managing Wastes From Reactors and Post Fission Operations in the LWR Fuel Cycle</u> , ERM-76-43, May 1976, Vol. 3, p. 22.13-22.17, plus current information.			

NFS has handled four cask types: NFS-1, NFS-2, NFS-4, and WECK. All but the NFS-4 are out of service. GE has also handled four cask types: IF-100, IF-200, IF-300 and MAC-1 (same as NFS-4). Of these, only the IF-300 and the MAC-1 remain in service. A summary of available spent fuel casks in the United States is shown in Table 1.

U.S. Spent Fuel Transport Experience

The transport of spent fuel casks is a relatively straightforward operation. Common carriers, either trucking companies or railroads, are used to move the spent fuel casks. Of the trucking companies, Tri-State Motor Transit Company handles a large number of the shipments that have been made in the United States. Tri-State owns a fleet of ten trailers, which accommodate the MAC-1, NFS-4, NLI-1/2 and can be adapted to the TN-8 and TN-9 casks. Tri-State also has a trailer for carrying the special cask used to transport the Peach Bottom I test reactor fuel.

Other trucking companies have also made nuclear shipments or have expressed interest in shipping nuclear materials and are potential future transporters.

The U.S. railroads have on several occasions attempted to: refuse to carry spent fuel shipping casks under the common carrier tariff regulations insisting that such shipments represent a risk above that normally accepted by the carrier (this provision extends to empty as well as loaded casks). The first three cases have been ruled upon by the Interstate Commerce Commission. Their finding was that the shipment of spent fuel casks did not constitute an unusual hazard and that the railroad should treat shipment of these systems as common carriers so long as the casks meet all of the packaging and regulatory requirements of DOT and NRC.* All of the currently licensed U.S. rail casks (the NLI-10/2 and GE IF-300) utilize auxiliary cooling systems on the railcar and complex tiedown systems; therefore, special purpose railcars are used to transport these casks. It is expected that special design railcars will also be provided for future design rail casks.

Spent Fuel Originating Systems

All nuclear power plants are potential originating stations or shippers of spent fuel. Some utilities in the United States have made spent fuel shipments to the reprocessing facilities of the NFS or to the GE-HSF or between reactor spent fuel pools within a utility or utility group. However, most United States utilities have not yet begun their shipment of spent fuels to Away-From-Reactor (AFR) storage sites or to reprocessing facilities.

A list of the utilities that have shipped spent fuel assemblies is shown in Table 2. A summary of Table 2 is shown that there have been 906 spent fuel assemblies transferred between spent fuel pools within a reactor site (i.e., no off-site transportation). In addition, there have been 3891 spent fuel assemblies shipped from reactor sites to other locations.

*The U.S. Supreme Court, in October 1980, declined to review the Sixth Circuit's decision to uphold the ICC rulings.

Table 2. U.S. Spent Fuel Shipments - Commercial Power Reactors³ (Compiled by Fuel-trac, Nuclear Assurance Corporation, Atlanta, GA, September 1979)

Utility/Reactor	Assemblies Shipped	Date
<u>Carolina Power and Light</u>		
H.B. Robinson to Brunswick	56	1977-1978
	126	1978-1979
(shipments continuing until 304 transferred)		
H.B. Robinson to INEL*	1	1975
Brunswick 2 to Brunswick 1	144	1978
<u>Commonwealth Edison</u>		
Dresden 1 to NFS	181	1964
	97	1966
	200	1967
	106	1969
	96	1970
	96	1971
	113	1973
Dresden 1 to GE-Vallecitos	1	1964
Dresden 1 to Savannah River	8	1964
Dresden 1 to B&W-Lynchburg	1	1973
Dresden 1 to INEL	2	1973
	1	1978
Dresden 2 to GE-MSF	244	1976
	509	1976-1977
Dresden 2 to BCL**	1	1976
<u>Connecticut Yankee Atomic Power Company</u>		
Conn Yankee to GE-MSF	80	1974-1975
<u>Consolidated Edison Company</u>		
Indian Point 1 to NFS	124	1966-1969
	80	1969
	40	1971-1972
<u>Consumers Power Company</u>		
Big Rock Point to NFS	48	1970
	139	1971
	72	1973
	13	1974
<u>Dairyland Cooperative</u>		
LaCrosse to Savannah River	1	1973
LaCrosse to GE-MSF	8	1979
<u>Duke Power Company</u>		
Oconee to B&W-Lynchburg	1	1975
(and return)	1	1976
	2	1978
Oconee to Crystal River	4	1978
Oconee to Oconee	131	1976-1977
	153	1978-1979

Table 2 (cont)

Utility/Reactor	Assemblies Shipped	Date
<u>Florida Power and Light Company</u>		
Turkey Point to Turkey Point	206	1976-1977
	272	1977-1978
Turkey Point to BCL	5	1978
<u>Jersey Central Power and Light Company</u>		
Oyster Creek to NPS	224	1975
<u>Pacific Gas and Electric Company</u>		
Humboldt Bay to NPS	270	1971
<u>Philadelphia Electric</u>		
Peach Bottom 2 to INEL	2	1976
<u>Rochester Gas and Electric</u>		
R.E. Ginna to NPS	121	1973-1975
<u>Southern California Edison</u>		
San Onofre 1 to GE-MSF	74	1972-1973
	21	1975
	55	1976
	104	1977-1978
	(will continue in 1979)	
<u>Wisconsin Electric Power Company</u>		
Point Beach to NPS	44	1974
	76	1975
Point Beach to GE-MSF	34	1975
	38	1976
	35	1977
Point Beach to BCL	2	1976-1977
(and then to GE-MSF)	2	
<u>Yankee Atomic Power Company</u>		
Yankee Rowe to NPS	74	1964
	39	1965
	37	1966
	38	1967
	36	1968
	36	1970
	36	1971
	36	1972
*INEL, Idaho National Engineering Laboratory		
**BCL, Battelle, Columbus Laboratories		

U.S. Experience - Transportation of Commercial High
Level Radioactive Waste (HLW)⁴

To date there have been no shipments of high level wastes associated with commercial nuclear fuel cycles in the United States. The high level wastes associated with the U.S. defense program have been generated and stored on government reservations and, hence, have not been transported off these reservations by common carrier.

Transportation Accident/Incident Experience⁵

Since 1971, a uniform multimodal Hazardous Material Incident (HMI) reporting system has been in effect in the United States as a requirement of DOT regulations. Carriers of hazardous materials are required to report all transport incidents to the DOT. The criteria for reporting include: death, personal injury, property damage and in the case of radioactive materials, suspected radioactive contamination. The totals of these hazardous materials incident reports through calendar year 1978 are shown in Table 3.

Table 3. Hazardous Material Incident Summary 1971-78^{5,6}

	1971-1975	1976	1977	1978	Totals (71-78)
All Other Hazardous Materials	31,674	12,001	15,384	18,058	77,312
Radioactive Materials	144	62	93	90	389
SUB TOTALS	32,018	12,063	15,477	18,143	77,701

A. W. Grella,⁵ provides a detailed summary of the HMI reports for the period 1971-75 and this analysis is currently being extended at Sandia National Laboratories through 1978. Grella determined that the road and rail transport modes, which are the pertinent transport modes for spent fuel movement, produced 70 of the 144 HMI reports. Of these 70 incident reports, 24 reports indicated a release of radioactive contents. It is important at this point to make note of a distinction that can only be determined by the detailed examination of the HMI reports and any attached documentation; that is, all hazardous material incidents are not transport accidents. For example, a detailed study of the HMI reports reveals that a significant number of cases involve minor cask or trailer contamination that has occurred during normal (incident free) transport operations.

The conclusions in Reference 5 were based upon the experience in the United States for the period 1971-75 and it was noted that radioactive material incidents comprised a small fraction of the total of all hazardous material incidents. The totals through 1978 still verify this type of response since radioactive material incidents represent only 0.5 percent of all hazardous material incidents. The releases that were noted in Reference 5 frequently involved Type A packages that contain such limited quantities of radioactive material that if a complete release of the radioactive contents were to occur, as a result of a transport accident, there could be no significant radiological

consequence. These Type A packages are, of course, not of the same integrity as a massive spent fuel package.

Sandia National Laboratories is currently examining DOT and NRC records in order to extend the work of Grella⁴ to the present. This work has not been completed but a summary of some recent United States transport experience that has occurred since January 1978 for spent fuel or similar transport systems is shown in Table 4. The purpose of the tabulation is to present a digest of actual radioactive material transport experience. The events in Table 4 were taken from NRC records for incidents involving all classes of RAM shipments during calendar 1978.

One can readily observe from Table 4 some recent experiences in the United States involving radioactive materials (RAM). Very little spent fuel transport is actually occurring as mentioned earlier. The accident experience is predominated by highway (truck) transport mode (this should be expected since little rail movement is occurring). There has been little or no radiological health hazard produced by these transport accidents. A detailed examination of the HMI reports reveals that in many cases the cause of the incident was the "leaching out" of surface contamination during normal (incident free) transportation.

Concluding Remarks

The primary aim of this item has been to present the limited information available on the United States experience involving the transportation of spent fuel and high level reactor wastes. The limited number of shipments of commercial spent reactor fuel is a reflection of United States policy in this area. There have been no commercial high level wastes shipped to date. This work is preliminary but part of an ongoing effort to tabulate and evaluate RAM transport accident statistics and, in general, determine the nature of the transportation accident environment. When the RAM transport accident analysis referred to above is completed, it is expected that a definitive statement can be made relative to the number of significant releases that have occurred in the U.S. from Type B packages used for the transport of spent fuel or high level waste; to date we know of no such incidents. This information, when coupled with more detailed risk analyses, allows the systematic determination of the risks involved with radioactive material transportation operations.

Table 4. United States RWH Transport Accidents Involving Fuel Cycle Materials* (Calendar Year 1978)⁷

Accident Date	Accident/Incident Description	Transport Mode	Material Type	Package Description	Contamination/ Exposure
Feb 78	Trailer buckled	Highway	Irradiated mixed oxide fuel	Spent fuel cask	None
Feb 78	No accident	Highway	Empty	Spent fuel cask	Slight contamination of cask outer surface
Feb 78	No accident	Highway	Empty	Spent fuel cask	Slight contamination of cask outer surface
Feb 78	Package fell off truck	Highway	Bounded resins	DOT approved package	None
Mar 78	No accident	Highway	Empty	Waste shipping cask	Slight contamination of cask outer surface
Apr 78	Truck overturned	Highway	Empty	Rad waste shipping cask	None
May 78	Lid of container missing	Highway	Low level waste	Plywood box	None
May 78	Improper packaging	Highway	Liquid fillers	DOT approved package	None
May 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Jul 78	No accident	Highway	Solid depleted U waste	55 gal drum	Slight contamination of truck only
Jul 78	No accident	Highway	Empty	Spent fuel shipping cask	Slight contamination of cask outer surface
July 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Aug 78	Cash brake truck bed	Highway	Empty	Rad waste shipping cask	None
Aug 78	Truck overturned	Highway	Solidified reactor waste	55 gal drum	None
Aug 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Sep 78	Lifting yoke broke trailer floor	Highway	Contaminated lifting yoke	-	None
Dec 78	Truck overturned	Highway	Solidified depleted U waste	Metals drums	None
Dec 78	Freezing	Highway	Low level waste	55 gal drum	Slight contamination of truck only

*Bank end of fuel cycle only.

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For more information contact Robert M. Jefferson (505 844-4296) or James D. McClure (505 844-8753).

THE INTERSTATE COMMERCE COMMISSION CASES

Over the years, rail carriers in different parts of the United States have taken variant positions as to their carriage of radioactive materials. These positions have been considered in various Interstate Commerce Commission (ICC) proceedings. Railroad tariffs for radioactive materials first were published in 1962. At the same time, the Eastern Territory railroads asserted that they were not common carriers of spent nuclear fuel or radioactive waste materials. These railroads refused to participate in the uniform tariffs published by the Nation's railroads and effective in other parts of the United Freight Classification, the uniform tariff published by the Uniform Classification Committee on behalf of all the Nation's railroads. They also failed to publish an alternative tariff, insisting that shippers sign separate contracts for each shipment. ICC proceedings involving the Eastern railroads were commenced in 1976 when a number of shippers (including then ERDA) filed formal complaints.

In November 1974, a Western carrier, the Missouri-Kansas-Texas Railroad Company (M-K-T), followed the Eastern railroads' lead announcing in a notice to the ICC (or flag-out) that it would no longer hold itself out as a common carrier of spent nuclear fuel or radioactive waste materials. Shortly thereafter, the M-K-T filed similar flag-outs for non-irradiated nuclear fuel and empty containers or cars if used previously to ship radioactive materials. No other railroad in the United States before or since has refused to publish tariffs for fresh fuel or used empty containers. (In fact, the M-K-T's own expert witness testified that the carriage of these materials presented no safety problem.) The ICC's M-K-T proceedings resulted from the filing of protests by shippers (including then ERDA).

The third type of proceeding before the ICC involved the Commission's investigation of the Southern and Western railroads' tariff changes making special train service mandatory for shipments of spent fuel and waste. (These railroads had acknowledged their common-carrier status by their publication of tariffs for various radioactive materials, including spent fuel and waste.) The ICC's investigation followed the filing of protests by a number of shippers (including then ERDA).

Separate hearings in each of the three types of proceedings were held before the same ICC Administrative Law Judge during 1976 and 1977. The Judge issued initial decisions favorable to the shippers in each of the proceedings, although his consideration of safety and insurance-indemnity issues went beyond what shippers and the Nuclear Regulatory Commission argued was the ICC's jurisdiction. The M-K-T decision was affirmed by Division 2 of the ICC (a panel of Commissioners) in November 1977 and by the full Commission in February 1978. Both appellate rulings stated that the Judge had gone too far in considering safety issues, indicating that such matters have been entrusted by Congress to the Nuclear Regulatory Commission and the Department of Transportation. The M-K-T cancelled its flag-outs effective April 27, 1978.

The Special Train Service proceeding decision was affirmed in March 1978 by Division 2, whereupon the Southern and Western railroads cancelled the mandatory special train provision effective April 14, 1978. Subsequently, the Department of Energy commenced an ICC reparations action to seek the return of overcharges for special train service not requested. The ICC has determined that DOE is entitled to reparations and DOE has submitted claims totalling approximately \$2,068,000 to the various railroads. The reparations case still is pending, with one group of carriers having sought review of the Commission's actions in the U.S. Court of Appeals for the District of Columbia Circuit and one group having been granted full commission review.

May 1981
ITEM TTC/010
Page 2

The ICC's Administrative Law Judge ordered the Eastern railroads to publish tariffs in a 1978 decision. That decision was affirmed by Division 2 of the ICC and the full Commission the same year. It also was affirmed in 1979 by the U.S. Court of Appeals for the Sixth Circuit. The Supreme Court of the United States declined to review the Sixth Circuit's decision in 1980.

After failing to have the courts overturn or stay the ICC's decision, the Eastern railroads in 1978 published "trainload service" tariffs for spent fuel and waste. That action has resulted in yet another ICC proceeding. The shippers (including DOE) in November 1978 protested that those tariffs amounted to a mandatory special train requirement whereupon the ICC in December 1978 commenced another investigation proceeding. That proceeding still is pending, and is currently awaiting decision from the U.S. Court of Appeals for the District of Columbia Circuit. The ICC decision, however, has held that "trainload service" (i.e., special trains) is unnecessary.

For more detailed information contact Joseph Distefano, Assistant General Counsel, U.S. DOE, Washington, DC 20585.

FACTORS IN TRANSPORTING RADIOACTIVE MATERIALS

Transport Statistics

There are approximately 500 billion packages shipped each year in the United States. About 100 million of these packages involve hazardous materials, including flammables, explosives, poisons, corrosives and radioactive materials [1].

An extensive survey of the total number of packages of radioactive material shipped in the United States was conducted in 1975 by Battelle, Pacific Northwest Laboratories [2]. This survey is in the process of being updated.

TABLE I
Summary of Information in Reference 2

Survey Group	Licensee Population	Packages Shipped per Year (Extrapolated value)
SNM/Source Material Shippers	906	400,000
Non-SNM/Source Material Shippers	1,049	1,100,000
Minor Shippers	13,950	200,000
Apparent Major Shippers	21	<u>800,000</u>
		2,500,000

Thus, the 100 million packages of hazardous materials represent about .02 percent of all of the packages shipped in a given year. The radioactive material shipments represent about 2 percent of the 100 million hazardous material packages.

Form of the Radioactive Material

SPECIAL FORM RADIOACTIVE MATERIALS - These materials which, if released from a package might present some direct radiation hazard but would present little hazard due to radiotoxicity and little possibility of contamination. Generally this would mean an indispersible solid radioactive material or a sealed capsule containing radioactive material.

NORMAL FORM RADIOACTIVE MATERIAL - These materials which do not meet the requirements stated above for Special Form Radioactive Materials. Normal Form radioactive materials are grouped into "transport groups."

Transport Groups

Any one of seven groups into which normal form radionuclides are classified according to their radiotoxicity and their relative potential hazard in transportation. (See Par. 173.390, Code of Federal Regulations, Part 49, Transportation.) (Table I)

Quantities

1. Type "A" Quantity Radioactive Material That material which may be transported in Type A packaging.*
2. Type "B" Quantity Radioactive Material That material which may be transported in Type B packaging.**
3. "TYPE A" QUANTITIES, "TYPE B" QUANTITIES, "LARGE QUANTITIES"
 - a. "Type A Quantity" and "Type B Quantity" means quantities the aggregate radioactivity of which does not exceed that specified in Table II.
 - b. "Large Quantity" means a quantity of radioactive material, the aggregate radioactivity of which exceeds any one of those as shown in Table III.

The amount of material allowed in each class of package is determined by the particular radionuclide and the Type A or Type B quantity specification as stated above. It should be emphasized that Type A packaging is subjected to only the normal conditions of transport whereas Type B packaging is subjected to normal and hypothetical accident conditions of transport. The limited quantity of radioactive material that can be transported in a Type A package reduces the risk associated with the release of its contents.

*Type A Packaging. Packaging which is designed in accordance with the general packaging requirements of 49 CFR 173.24 and 173.393 and which is adequate to prevent the loss or dispersal of the radioactive contents and to retain the efficiency of its radiation shielding properties if the package is subjected to the tests prescribed in 49 CFR 173.398b, the Normal Conditions of Transport.

**Type B Packaging. Packaging which meets the standards for Type "A" Packaging, and in addition, meets the standards for the hypothetical accident conditions of transport as prescribed in Part 173.398C. Type B packages regulated by the NRC currently fall into two categories: those containing Type B quantities and those containing "large quantities" of radioactive material. The present upper limit for Type B quantities and the designation of amounts greater than that limit as "large quantity" were established at a time when large quantities of radioactive material, particularly in the form of irradiated fuel, were thought to require special provision for heat removal and special consideration of the possible escape of coolant under accident conditions. However, experience has shown that, while some present Type B quantities do require special consideration of heat removal, most large quantities do not require such consideration. Also, the hazard associated with escape of radioactive material is not appreciably dependent upon whether the accompanying non-radioactive material is classified as a coolant. Therefore, the proposed rule would combine the existing Type B and large quantities.

TABLE II
Type A and B Quantities

Transport Group	Type A Quantity (in curies)	Type B Quantities (in curies)
I	0.001	20
II	0.05	20
III	3.0	200
IV	20.0	200
V	20.0	5000
VI and VII	1000.0	50000
Special Form	20.0 ¹	5000

¹Except that for Californium-252 the Type A quantity limit for special form is 2 curies.
(Reference Par. 173.389)

TABLE III
Large Quantities

Transport Group	Large Quantity (in curies)
I or II	20
III or IV	200
V	5000
VI or VII	50000
Special Form	5000

Package Tests

The special tests in 49 CFR 173.398 are the same tests which represent the hypothetical accident environment that are also stated in Part 71, Title 10, U.S. Nuclear Regulatory Regulations, commonly referred to as 10 CFR 71. It is important to note that there is a Regulatory Guide 7.4, produced by the NRC, which gives guidance on the leakage tests on packages for shipment of radioactive materials. The regulatory guide 7.4 refers to the work of an American National Standards Institute Committee (ANSI N14.5) which produced the draft standard for these leakage tests. In short, the regulations state what tests are to be imposed upon a candidate package design. Regulatory Guide 7.4 and the report of the ANSI N14.5 committee state that the leakage rates must be met in order to pass the regulatory tests.

May 1981
ITEM TTC/011
Page 4

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For more detailed information contact James D. McClure (505 844-8753).

THE RISKS OF TRANSPORTING SPENT NUCLEAR FUEL BY TRUCKS

Risk, as this term is usually used in environmental impact assessments, means the probability of an event occurring per year multiplied by the consequences resulting from that event. The final statement of risk is usually phrased in terms of health effects, that is, fatalities. This description of risk implies that the probabilities of a particular event are known or can be estimated. Also assumed is that the consequences have been measured or have been calculated. In the case of spent nuclear fuel transportation, the event is usually thought of as an accident of sufficient severity to release materials which may cause adverse consequences.

Probabilities include frequencies of shipments and accidents. The current number of shipments (approximately 200 in 1981) is small and the anticipated number of future shipments is small when compared with the normal commerce involving large packages (containers) transported by truck or rail shipping systems. Accident rates are calculated on frequency per mile traveled. From five years of records reported by the Bureau of Motor Carrier Safety, accidents involving trucks occurred at the rate of one per 400,000 miles of travel or 2.5×10^{-6} accidents/mile. This accident rate represents the total of all reported accidents divided by the total miles driven. The release of spent fuel from such an event would not occur except in an extremely severe accident. Such accidents are not likely to occur more frequently than 1 in every 100 accidents and thus has a probability of less than 2.5×10^{-8} (per year).

The possible adverse consequences that may occur from an accident releasing some fraction of the shipment's nuclides are usually considered in terms of human health effects with specific emphasis on immediate and latent fatalities. In addition, adverse consequences also could include harm to the ecosystem, economic considerations and social disruption. Estimation of these consequences is accomplished by analysis since very little applicable data exist. These analyses are based on the characteristics and amounts of material assumed to be released in a severe accident, the weather conditions at the time of the accident population distribution in the area surrounding and assumed failure threshold of packages. Because actual data on consequences are limited for transportation of radioactive material, these analyses are based on estimates of and always include a release of these materials.

One other risk evaluation is performed in evaluating transport of spent fuel. Associated with each shipment of spent fuel is a radiation field which results from that radiation emitted from the material but not completely absorbed by the containment and shielding systems. The shipments are required to be within certain established federal standards for permissible exposure to handling and transport personnel. In terms of overall risk, a major factor is the estimated cumulative effect to those associated with the shipping processes. The risk in normal operations is low.

Since actual data describing risk are not available, the risks of transporting spent fuel have been calculated and are shown on the risk spectrum plot shown in Figure 1.¹ This plot shows the estimated number of fatalities versus the estimated frequency of a particular accident. Also included in this plot are other risks that society is exposed to for comparison purposes. The plot shows the overall risk of transporting spent fuel is small.

The risk spectrum for transporting spent fuel shown in Figure 1 also shows that the estimated probability that a shipment of spent fuel will be involved in an accident resulting in one or more fatalities during the referenced time period is 2.2×10^{-5} and the estimated probability of an event resulting in five or more fatalities is

5.0×10^{-6} . Risk spectra for other risks to which society might be exposed² and from transportation of other radioactive material,^{3,4} have been included in the figure for comparison. The curves in Figure 1 indicate that the risk of transporting spent fuel in the reference period is much less than the risk to society from natural events or man-caused events.

Figure 1. Risk spectra for spent fuel shipments in the mid-1980's for the entire United States.

Additional perspective may be gained on the risk of transporting spent fuel by truck by comparing the total risk and the risk to any individual in society with similar numbers for other risk-producing activities and natural events. The total risk from transporting 180-day cooled spent fuel by truck in the reference year is 4.5×10^{-5} fatalities. An individual in the population at risk would have one chance in 6×10^{11} of suffering a latent cancer fatality from a release of radioactive material from a truck carrying spent fuel in the reference year. Table I presents a comparison of these numbers to other risk-producing events in the United States. The risks from transporting spent fuel by truck in the reference year are seen to be much less than the risks from other man-caused events and lower than the risk from infrequent natural disasters such as meteorites.

TABLE I
Average Total and Individual Risk in the United States
from Various Accidents and Natural Disasters

Event	Total Risk (fatalities/year) ^a	Individual Risk ^b
All accidents	103,030	1 in 2,000
Motor vehicle accidents	46,700	1 in 4,000
Air crashes	1,552	1 in 130,000
Dam Failures	35 ^c	1 in 5,700,000
Air crashes (persons on ground)	6 ^d	1 in 33,000,000 ^e
Meteorites	1.0×10^{-3} ^f	1 in 2×10^{11}
Spent fuel truck shipments	4.5×10^{-5}	1 in 6×10^{11} ^e

^aBased on 1975 statistics unless otherwise noted.
^bBased on total U.S. population.
^cAverage for dam failures 1889-1972 (Reference 2).
^dAverage for years 1960-1973 (Reference 2).
^eBased on population at risk.
^fEstimate based on information from Reference 2.

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May 1981
ITEM TYC/012
Page 4

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For more information contact Edward W. Shepherd (505 844-1740).

TRANSPORT ACCIDENT RATES

The following accident rates have been derived by the referenced studies:

Aircraft accidents:	$R = 1.0 \times 10^{-8}$ accidents/mile [1]
Motor carrier accidents:	$R = 2.5 \times 10^{-6}$ accidents/mile [1,2]
Rail accidents:	$R = 1.0 \times 10^{-5}$ accidents/mile [1,2]
Barge accidents:	$R = 1.3 \times 10^{-5}$ accidents/mile (see below)
Ship loss:	$R = 1.5 \times 10^{-8}$ vessel loss/mile (see below)

Marine Transportation

Barge Transportation

The barge accident rates were determined as follows. An examination of the U.S. Coast Guard accident reports has been performed by C. A. Davidson of Sandia National Laboratories for the period 1965-1974. During this period, there were a total of 6090 barge accidents. The average size of a cargo barge is approximately 1200 tons. The ton mileage of U.S. traffic in 1975 was:

Coastal Traffic:	316×10^9 ton-miles [3]
Inland Traffic: (exclusive of Great Lakes)	243×10^9 ton-miles [3]
	<hr/>
	559×10^9 ton-miles

Average number of barge accidents per year = $6090/10 = 609$

Average number of barge miles traveled per year = $\frac{559 \times 10^9 \text{ ton-miles}}{1200 \text{ tons (avg barge)}}$
= 4.66×10^8 miles

Barge accident rate = $\frac{609 \text{ barge accidents/year}}{4.66 \times 10^8 \text{ miles/year}}$ = 1.3×10^{-6} barge accidents/mile

Ship Loss per year [4]

The probability of ship total loss/vessel kilometer,

Average value (years 1970/74) = 6.5×10^{-8} prob vessel loss/vessel km
= 12.0×10^{-8} prob vessel loss/vessel NM
= 10.5×10^{-8} prob vessel loss/vessel mile

The severity of transportation accidents, as reported in References 1 and 2 is generally described by the magnitude of selected engineering parameters which provide a measure of the severity (intensity) of the generic accident environment categories of impact, fire, crush, puncture and immersion. The severity parameters are characterized by, for example, impact velocity and target description for the impact environment and fire temperature and fire duration for the fire environment. The severity parameters have been related to probability of occurrence of the accident environment in References 1 and 2. The relationship between transportation accident severity and probability of occurrence of the accident environment can be used in essentially two ways: (1) to evaluate the adequacy of the qualification tests which are a part of transport packaging regulations, and (2) to study the nature of transport accidents in the extra-regulatory (very severe-low probability) transport accident environments which are more severe than the regulatory requirements. An analysis of the packaging regulatory requirements has been performed in Reference 5.

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For more detailed information contact James D. McClure (505 844-8753).

INTERNATIONAL LICENSING OF CASKS AND OTHER TYPE B PACKAGES

Introduction

The issue of international use of shipping casks and other Type B packages is rapidly becoming of more importance because of the impetus to solve proliferation problems by shipping spent fuel and other nuclear materials from sensitive locations to less sensitive areas. Such shipments will generally involve transfer between countries, and will probably involve shipments from diverse countries to the United States.

Status of Regulations

A summary of pertinent regulations follows.

IAEA Safety Series No. 6

The "Regulations for the Safe Transport of Radioactive Materials," 1973 Revised Edition, IAEA Safety Series No. 6, specifies requirements for Type B packagings. According to these regulations, shipping casks would be Type B packaging. The IAEA regulations provide for unilateral/multilateral approaches as follows.

Unilateral Approval

142.* Unilateral approval shall mean approval by the competent authority of the country of origin only (for international/multinational shipments).

Multilateral Approval

123. Multilateral approval shall mean approval by both the relevant competent authority of the country of origin and of each country through or into which the consignment is to be transported.

Type B Packaging

131. Type B Packaging shall mean a packaging that is designed to withstand the damaging effects of a transport accident as demonstrated by the retention of the integrity of containment and shielding, to the extent required by these Regulations, after the tests specified in Section VII, par. 709-721, as appropriate.

Type B(U) Package

127. Type B(U) package shall mean a Type B packaging, together with its radioactive contents, which, since it is designed in accordance with specified design and containment criteria, requires unilateral approval only of the package design and of any storage provisions that may be necessary for heat dissipation.

*Numbers indicate paragraph in Safety Series No. 6

Type B(M) Package

12B. Type B(M) package shall mean a Type B packaging, together with its radioactive contents, which, since its design fails to meet one or more of the specific additional design criteria for Type B(U) packages (see Section II, par. 234-241), requires multilateral approval of the package design and, in certain circumstances, of the conditions of shipment.

The Safety Series No. 6 is presently undergoing international scrutiny, and will be revised comprehensively in 1983. One action being considered is to "reconsider difference allowed in activities released in accidents between Type B(U) and B(M) packages."* However, the unilateral/multilateral philosophy will probably be retained.

U.S. Regulations

Current U.S. regulations encompass the 1967 revision of Safety Series No. 6, whereas most other nations have adopted the 1973 revision of Safety Series No. 6. Action has been initiated by DOT (HM-169, January 8, 1979) to adopt the 1973 regulations into 49 CFR, and a similar action has been taken by NRC (Federal Register, Vol. 44, No. 161, August 17, 1979) for 10 CFR. However, even when these actions are implemented, differences will exist between U.S. and international regulations. A notable example is that the Q/A requirements in Appendix E of 10 CFR 71 are more stringent than international requirements. As a result, foreign fabricated casks might not be acceptable for domestic use in the U.S. (import still allowed).

The current U.S. Regulations (49 CFR and 10 CFR) do not have the unilateral/multilateral approval specification. Therefore, any foreign package denoted B(U) would still require U.S. review and approval, and all U.S. packages will require foreign review and approval. One exception to this involves shipments from or to Canada. It is stated in 49 CFR 173.8:

- (a) Shipments of hazardous materials which conform to the regulations of the Canadian Transport Commission (formerly the Board of Transport Commissioners for Canada), may be transported from the point of entry in the United States to their destination in the United States, or through the United States en route to a point in Canada.
- (b) Except as specified in § 173.301(i), specification packages made and maintained in full compliance with the corresponding specifications prescribed by the Railway Transport Committee of the Canadian Transport Commission (formerly the Board of Transport Commissioners for Canada) in its regulations for the Transportation of Dangerous Commodities by Rail, and marked in accordance therewith (e.g., BTC, CTC, etc.) may be used for the shipment of hazardous materials within the United States.

*See Report of First Meeting of Standby Advisory Group on the Safe Transport of Radioactive Materials (SAGSTRAM), October 1978.

Current Certifying Policy

In the U.S., the NRC reviews and evaluates Type B packagings and indicates approval by issuing Certificates of Compliance approving use of the packaging domestically only. For international use of a U.S. package, the DOT must review and evaluate the packaging, and indicates approval by issuing a "Certificate of Competent Authority." Since the U.S. regulations are not consistent with Safety Series No. 6, revision 1973, this Certificate refers to the 1967 revision. Acceptance of these packages is then handled on a country-by-country basis, and it is incumbent upon the shipper or carrier to obtain foreign country approval.

One notable exception has recently occurred relative to this process. The country of Japan requires that a Safety Analysis Report be submitted to their competent authority and a Certificate of Compliance be issued before any packaging can be used within their boundaries.

Packagings certificated by other countries are reviewed by our Competent Authority and NRC before their use in the U.S. is approved. For example, 49 CFR 171.12 states:

- (a) Except in the case of a shipment from Canada conforming to 173.8, each person importing a hazardous material into the United States shall provide the shipper and the forwarding agent at the place of entry into the United States timely and complete information as to the requirements of this subchapter that will apply to the shipment of the material within the United States. The shipper, directly or through the forwarding agent at the place of entry, shall provide the initial carrier in the United States the certificate of compliance required by 172.204. The carrier may not accept the material for transportation unless the required certification is provided.

Future Certifying Policy

It is difficult to speculate on what future policy may be. However, if it is assumed that the 1973 revision of Safety Series No. 6 is implemented in the U.S. regulations, the procedure for either using U.S. casks in foreign countries or using foreign casks in the U.S. will be streamlined somewhat. This is especially true if future certifying actions at NRC lead to casks being B(U) approved.

Nonstandard Use of Packagings

Future international shipments may involve shipping radioactive materials in packagings which were not designed or certificated for specific material forms. Therefore, before use of such a package can be accomplished, an addendum to an existing certificate of compliance (and/or certificate of competent authority) will be required. Such nonstandard use may include designing and fabricating new strongbacks or fuel baskets. The aspects of the redesign, including structural, thermal and neutronic considerations must be addressed to the regulators in detail via an application for addendum to the certificate of compliance.

For more detailed information contact Ronald B. Pope SML/TTC (505 844-5445) or Richard Rawl, U.S. Competent Authority, Materials Transportation Bureau, U.S. DOT, Washington, DC 20590.

ALLIED GENERAL NUCLEAR SERVICES
P. O. Box 847
Barnwell, SC 29812
Attn: Paul F. Highberger

AMERICAN ASSOCIATION OF RAILROADS
1920 L Street, NW
Washington, DC 20036
Attn: Conan P. Furber

AMERICAN FRIENDS SERVICE COMMITTEE
92 Piedmont Avenue NE
Atlanta, GA 30303
Attn: William T. Reynolds

AMERICAN TRUCKING ASSOCIATION, INC.
1616 P Street, NW
Washington, DC 20036
Attn: R. M. Doyle

ARGONNE NATIONAL LABORATORY (2)
9700 South Cass Avenue
Argonne, IL 60439
Attn: J. Peterson
C. J. Roberts

ATOMIC INDUSTRIAL FORUM
7101 Wisconsin Avenue
Bethesda, MD 20014
Attn: E. Gordon

AUBURN FIRE DEPARTMENT
23 Market Street
Auburn, NY 13021
Attn: W. D. Maywalt

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratory
505 King Avenue
Columbus, OH 43201
Attn: C. C. Kimm

BATTELLE MEMORIAL INSTITUTE (2)
Office of Nuclear Waste Isolation
505 King Avenue
Columbus, OH 43201
Attn: T. I. McSweeney
Reuben W. Peterson

BATTELLE MEMORIAL INSTITUTE
Human Affairs Research Center
4000 N.E. 41st Street
Seattle, WA 98105
Attn: Hank Schilling

BATTELLE MEMORIAL INSTITUTE
Pacific Northwest Laboratory
P. O. Box 999
Richland, WA 99352
Attn: Kenneth J. Schneider

CITY AND COUNTY OF DENVER
Department of Fire
Fire Prevention Bureau
745 West Colfax Avenue
Denver, CO 80204
Attn: J. H. Marshall

CITY OF MISSOULA
Missoula, MT 59801
Attn: Bill Boggs

CITY OF NEW ORLEANS
City Hall - Room 8E06
New Orleans, LA 70112
Attn: Gino Carlucci, Jr, Director
Environmental Affairs

CITY OF NEW YORK
Radiation Control Bureau
377 Broadway
New York, NY 10013
Attn: Leonard R. Solon, Director

CITY OF WATERFORD
200 Boston Post Road
Waterford, CT 06385
Attn: Larry Bettencourt, First Electman

CONSULTANT
Thomas A. Duffey
PO Box 4804
Station A
Albuquerque, NM 87106

CONSULTANT
Kenneth A. Gablin
6749 Towne Lane Road
McLean, VA 22101

CONSULTANT
Fred Gelbard
Massachusetts Institute of Technology
Department of Chemical Engineering
Room 66-442
Cambridge, MA 02139

CONSULTANT
Michael Huerta
PO Box 9761
El Paso, TX 79967

CONSULTANT
Robert H. Jones
PO Box 24036
San Jose, CA 95154

CONSUMER HEALTH DEPARTMENT
Kinkaid Building
505 East King Street
Carson City, NV 89710
Attn: John Vaden

COUNTY OF EDDY
P. O. Box 1658
Carlsbad, NM 88220
Attn: Robert S. Light

EG&G (6)
Idaho National Engineering Laboratory
P. O. Box 1625
Idaho Falls, ID 83415
Attn: Dennis Adams
G. D. Levin
Ralph W. Marshall
Craig F. Nern
John Peel
Pat Serie

E. I. DUPONT DE NEMOURS AND COMPANY, INC.
Savannah River Plant
Aiken, SC 29801
Attn: L. A. Boydston

FEDERAL EMERGENCY MANAGEMENT AGENCY
1725 Eye Street NW
Washington, D.C. 20472
Attn: Joe D. Winkle, Director
Federal Response Coordination

GENERAL ATOMIC COMPANY (2)
P. O. Box 81608
San Diego, CA 92138
Attn: Robert Burgoyne
Nicki Hobson

GENERAL ELECTRIC COMPANY
175 Curtner Avenue
Mail Code 861
San Jose, CA 95125
Attn: Robert K. Stitt

HAZARDOUS MATERIALS ADVISORY COUNCIL
1100 17th St., N.W., Suite 908
Washington, DC 20036
Attn: Executive Director

H&R TECHNICAL ASSOCIATES, INC.
P. O. Box 215
Oak Ridge, TN 37830
Attn: W. R. Rhyne, Vice President

INTERNATIONAL ENERGY ASSOCIATES, LTD. (2)
600 New Hampshire Ave. N.W.
Washington, DC 20037
Attn: K. E. Leslie-Ross
B. W. Welles

LAURA KEEVER
10515 Laneview
Houston, TX 77070

LEBOEUF, LAMB, LEIBY AND MACRAE
Suite 1100
1333 New Hampshire Avenue NW
Washington, DC 20037
Attn: Leonard M. Trosten

MONSANTO RESEARCH CORPORATION
Mound Facility
P. O. Box 32
Miamisburg, OH 45342
Attn: Don A. Edling

MORGAN STATE UNIVERSITY
Center for Transportation Studies
Baltimore, MD 21239
Attn: R. P. Capelle, Jr.

NATIONAL COMMITTEE ON UNIFORM TRAFFIC
LAWS AND ORDINANCES
801 North Glebe Rd., Suite 400
Arlington, VA 22203
Attn: E. F. Kearney

NATIONAL CONFERENCE OF STATE LEGISLATURES (50)
1125 17th Street
Suite 1500
Denver, CO 80202
Attn: Ms. Julia Jordan

NATIONAL GOVERNORS' ASSOCIATION
444 North Capitol Street
Washington, DC 20001
Attn: Charilyn W. Cowan

NATIONAL HIGHWAY TRANSPORTATION SAFETY
ADMINISTRATION
400 7th Street, SW
Washington, DC 20590

NATIONAL RESEARCH COUNCIL
Railroad Research Information Service
Transportation Research Board
2101 Constitution Avenue, NW
Washington, DC 20418
Attn: F. N. Houser, Manager

NATIONAL TANK TRUCK CARRIERS, INC.
1616 P Street, NW
Washington, DC 20036
Attn: Clifford J. Harvison

NATIONAL TRANSPORTATION SAFETY BOARD
TE-40
Washington, DC 20594
Attn: Ludwig Benner

NEW ENGLAND NUCLEAR CORPORATION
601 Treble Cove Road
North Billerica, MA 01862
Attn: Ernest DeMaria

ML INDUSTRIES
P. O. Box 2046
Wilmington, DE 19899
Attn: Charles Williams

NORTHEAST UTILITIES (2)
P. O. Box 270
Hartford, CT 06101
Attn: Robert W. Bishop,
Secretary & Counsel
Attn: Faith N. Branneman

NUCLEAR ASSURANCE CORPORATION (2)
24 Executive Park West
Atlanta, GA 30329
Attn: Paul Schutt, President
Charles C. Hoffman, Manager
Cask Operations

MUS CORPORATION (2)
4 Research Place
Rockville, MD 20850
Attn: N. B. McLeod
Yong Park

OAK RIDGE NATIONAL LABORATORY (2)
P. O. Box X
Oak Ridge, TN 37830
Attn: K. S. Notz
L. Shappert

POTOMAC ALLIANCE
1743 Q Street NW
Washington, D.C. 20009
Attn: Fred Miller

SIERRA CLUB
3164 Main Street
Buffalo, NY 14214
Attn: Marvin Rusnikoff

SOUTHERN STATES ENERGY BOARD
One Exchange Place, Suite 1230
Atlanta, Georgia 30338
Attn: Library

SOUTHWEST RESOURCE & INFORMATION CENTER
P. O. Box 4524
Albuquerque, NM 87105
Attn: Donald Hancock, Executive Director

STATE OF CALIFORNIA
Energy Commission
1111 Howe Avenue
Sacramento, CA 95825
Attn: Barbara Jost, M/S 2

STATE OF CONNECTICUT
Governor's Office
Hartford, CT 06115
Attn: Mary Hart

STATE OF NEW MEXICO
Division of Health and Environment
P. O. Box 968
Santa Fe, NM 87503
Attn: Ted Wolff

STATE OF NEW YORK
Department of State
162 Washington Avenue
Albany, NY 12231
Attn: David E. Buerle
Coastal Energy Coordinator

STATE OF OHIO
30 East Broad Street - 17th Floor
Columbus, OH 43215
Attn: Dennis Muchnick
Assistant Attorney General
Environmental Law Section

STATE OF TEXAS
Department of Health
Radiation Control Branch
1100 West 49th Street
Austin, Texas 78756
Attn: E. D. Bailey

STATE OF VIRGINIA
Department of Health
927 Madison Building
109 Governor Street
Richmond, VA 23219
Attn: William Gilley

STATE OF WISCONSIN
Governor's Office
Madison, WI 53702
Attn: Dave Woodbury

STATE PLANNING COUNCIL (3)
Suite 605
1900 L Street NW
Washington, D.C. 20036
Attn: John H. Denick
John Stucker, Executive Director
Laura Worby

THOMAS GRAY ASSOCIATES
815 N. Main Street
Orange, CA 92668
Attn: Thomas Gray, President

ELLIOTT D. THOMPSON
P. O. Box 11537
Columbia, SC 29211

TRANSNUCLEAR
One North Broadway
White Plains, NY 10601
Attn: Bill Teer

TRI-STATE MOTOR COMPANY (2)
P. O. Box 113
Joplin, MO 64801
Attn: Charles H. Mayer, Vice President
Nuclear Division

UNION CARBIDE CORPORATION
270 Park Avenue
New York, NY
Attn: Stanley Hoffman, Esq.
Transportation Counsel

UNITED PARCEL SERVICE
51 Weaver Street, Office Park 5
Greenwich, CT 06830
Attn: Ronald R. Hinkle

UNIVERSITY OF NEW MEXICO
Albuquerque, NM 87131
Attn: Roger Norton,
Professor of Economics

U.S. CONFERENCE OF MAYORS
1620 Eye Street, NW
Washington, DC 20006
Attn: Fredie Diane Kay
Emergency Preparedness Staff

U.S. DEPARTMENT OF ENERGY (3)
San Francisco Operations Office
1333 Broadway
Oakland, CA 94612
Attn: Area Manager
Traffic Manager
L. Lani

U.S. DEPARTMENT OF ENERGY (2)
Rocky Flats Area Office
P. O. Box 298
Golden, CO 80401
Attn: Area Manager
Traffic Manager

U.S. DEPARTMENT OF ENERGY (12)
Office of Nuclear Energy
Washington, DC 20545
Attn: T. Anderson, NE-340
F. P. Falci, NE-340
J. Fiori, NE-340
R. F. Garrison, NE-340
O. P. Gornley, NE-340
Elizabeth Jordan, NE-320
M. J. Lawrence, NE-340
E. F. Mastel, NE-313
S. Meyers, NE-30
R. C. Romatowski, NE-30
J. A. Sisler, NE-340
V. G. Trice, NE-313

U.S. DEPARTMENT OF ENERGY (2)
Washington Library
Washington, DC 20545
Attn: Energy Library/AD-453
Energy Library/AD-452

U.S. DEPARTMENT OF ENERGY (3)
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401
Attn: Area Manager
Chief, Rad Waste Mgmt Branch
Traffic Manager

U.S. DEPARTMENT OF ENERGY (2)
Chicago Operations Office
9800 South Cass Avenue
Argonne, IL 60439
Attn: Area Manager
Traffic Manager

U.S. DEPARTMENT OF ENERGY (5)
Albuquerque Operations Office
Albuquerque, NM 87115
Attn: K. Carlson, Transp Program Mgr
E. C. Hardin, Jr., Actg Deputy
Asst Mgr, Office of Projects &
Energy Programs
R. Y. Lowrey, Director, Waste
Mgmt & Transp Development
W. C. Purchase, Traffic Manager
D. Schueler, WIPP Program Manager

U.S. DEPARTMENT OF ENERGY (2)
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114
Attn: Area Manager
A. Neumann, Traffic Manager

U.S. DEPARTMENT OF ENERGY (2)
Brookhaven Area Office
Upton, NY 11973
Attn: Tech. Asst. to the Area Manager
Traffic Manager

U.S. DEPARTMENT OF ENERGY (2)
Dayton Area Office
P. O. Box 66
Miamisburg, OH 45342
Attn: Area Manager
Traffic Manager

U.S. DEPARTMENT OF ENERGY (3)
Savannah River Operations Office
P. O. Box A
Aiken, SC 29801
Attn: M. C. Kirkland
M. K. Sasser
Traffic Manager

U.S. DEPARTMENT OF ENERGY (2)
Oak Ridge Operations Office
P.O. Box E
Oak Ridge, TN 37830
Attn: Area Manager
L. Blalock, Traffic Manager

U.S. DEPARTMENT OF ENERGY (2)
Richland Operations Office
P. O. Box 999
Richland, WA 99352
Attn: Area Manager
Traffic Manager

U.S. DEPARTMENT OF TRANSPORTATION (4)
400 Seventh Street SW
Washington, D.C. 20590
Attn: Doug Crockett, DMT-1, Room 8102
Richard R. Rawl, MTB
Alan I. Roberts, MTB
Lee Santman

U.S. ENVIRONMENTAL PROTECTION AGENCY
401 M Street, NW
Washington, DC 20460
Attn: Ray Clark

U.S. HOUSE OF REPRESENTATIVES
Committee on Public Works & Transportation
B-376 Rayburn House Office Building
Washington, DC 20515
Attn: George M. Kipecky, Staff Director

U.S. NUCLEAR REGULATORY COMMISSION (6)
Washington, DC 20555
Attn: Norman L. Eisenberg, M/S ML-5650
Alfred W. Grella, M/S EN-359
Donald R. Hopkins, M/S ML-5650
Charles E. MacDonald, MS/ 396-SS
James C. Malero, M/S 305-SS
Anthony M. Tse, ML-5650

1233 J. M. Taylor
1700 W. C. Myre
4000 A. Marath
Attn: G. Yonas, 4200
R. L. Peurifoy, Jr., 4300
J. H. Scott, 4700

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